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Towards an Activity-Oriented Design Method for HCI research and practice

by

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(MSc HCI; BSc (Hons) IT)

Thesis submitted in partial fulfilment of the requirements for
the degree of Doctor of Philosophy
in Human-Computer Interaction



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Dedications

To the belated memory of my dearly beloved mum - Alice Munsanje Ng'ake:

Long gone but never forgotten!

To my ever beloved son - Chilobe Wakung'uma Mwanza:

Promises made are promises kept!

To my dear parents - Mr and Mrs W.H. Mwanza:

For making many things possible!

Abstract

During the last two decades, designing for *usability* has been the focus of attention when developing computer systems. However, the dynamic nature of human use of computer systems has meant that designing for '*usefulness*' or '*fitness for purpose*' is increasingly becoming the primary concern for systems developers. Central to this concern are issues underpinned by the social context in which a computer user operates.

Within the field of Human-Computer Interaction (HCI), this situation led to a search for appropriate theories for conceptualising these design concerns. Whilst Activity Theory has been identified as a suitable framework for conceptualising these user perspectives, the lack of a standard methodology for applying it to HCI research and practice has meant that many systems developers have failed to benefit from the richness of this framework. The objective of this thesis was therefore to develop an Activity Theory based methodology for HCI research and practice. This thesis, contributes the 'Activity-Oriented Design Methodology' (AODM) both as a practical and analytical methodology for using Activity Theory within HCI design. AODM incorporates four methodological tools namely:

- The 'Eight-Step-Model'
- The 'Activity Notation'
- The technique of 'Generating Research Questions'
- The technique of 'Mapping AODM Operational Processes'

AODM tools were constructed from empirical work carried out as part of this research. Empirical analysis of work practices in two organisations was conducted for a period of two years using Activity Theory. This empirical work formed the basis for validating AODM. AODM tools support the systems design processes of gathering, analysing and communicating (through modelling) research and design insights from an Activity Theory perspective. It is argued that AODM provides a valuable practical and analytical methodology for operationalising Activity Theory within HCI so as to support early phases of systems design: namely, requirements capture and evaluation.

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"If I have seen further, it is by standing on ye shoulders of giants."

Sir Isaac Newton (1642 to 1727)

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Daisy Mwanza

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List of Published Papers

The following published papers developed out of the research carried out as part of this PhD research.

Journals

- Mwanza, D., (2002) “Conceptualising work activity for CAL systems design.” In the *Journal of Computer Assisted Learning* (Eds. R. Lewis & R. Joiner), Vol. 18 (1), pp.84-92, March, 2002, Blackwell Science Ltd, UK.

Conference Proceedings

- Mwanza, D., (2001) “Where Theory meets Practice: A Case for an Activity Theory based Methodology to guide Computer System Design.” In Michitaka Hirose (Ed), *Proceedings of INTERACT'2001: Eighth IFIP TC 13 International Conference on Human-Computer Interaction*, Tokyo, Japan, July 9-13, 2001. IOS Press Oxford, UK.
- Mwanza, D., (2001), “Changing Tools Changing Attitudes: Effects of introducing a computer system to promote learning at work.” In Dillenbourg, P., Eurelings, A., and Hakkarainen, K., (Eds (2001)), “European Perspectives on Computer-Supported Collaborative Learning.” *Proceedings of Euro-CSCL'2001: The First European International Conference on Computer-Supported Collaborative Learning*, March 22-24, 2001, University of Maastricht, The Netherlands.
- Mwanza, D., (2001), “Challenges of designing for collaborative learning in an organisation.” In the abstract *Proceedings CAL 2001: International Conference on Computers And Learning*. University of Warwick, Coventry, UK. April 2-4, 2001. Paper won an **Outstanding Contribution Award**

- Mwanza, D., (2001) “Practical Perspectives on Activity Theory.” In the abstracts *Proceedings of ICCPL'2001: International Conference on Communication, Problem Solving and Learning*. University of Strathclyde, Glasgow, UK. 25th - 29th June, 2001.

Technical Reports and Workshops

- Mwanza, D., (2000) “Mind the Gap: Activity Theory and Design,” *KMi Technical Reports (KMI-TR-95)* Knowledge Media Institute, The Open University, Milton Keynes, UK.
- Mwanza, D., (2000) “From Theory to Design: Challenges of applying Activity Theory to the Design of a Computer System.” *Computers And Learning Research Group Annual Conference*. Institute of Educational Technology (IET), The Open University, Milton Keynes, UK.
- Mwanza, D., (1999) “ENRICH-ing Computer tool Design using Activity Theory.” *3rd Human Centred Technology (HCT) Postgraduate Workshop*, School of Cognitive and Computing Sciences, University of Sussex, Brighton, UK. 30th September - 1st October 1999.

Chapter One

1. Introduction

This thesis represents part of a wider effort within the field of Human-Computer Interaction (HCI) to leverage the use of theories for systems design purposes. The use of theories to inform HCI design introduces a lot of challenges to systems design. Perhaps most significant of these design challenges, is the inevitable need for well-established methods for applying these theories within HCI research and practice. This thesis is offered as a contribution in this respect by developing and proposing a theory informed method for use within HCI research and practice.

This chapter begins by presenting a brief background to the research concern addressed in this thesis. These discussions form the basis for identifying the outlined research problem. Thereafter, a section introducing the research approach employed during the investigation is presented. This is followed by discussions of the thesis contributions. Finally, an outline of the thesis structure describing the contents of the remaining chapters is given.

1.1 Research Background

Computer systems design has traditionally been informed by the field of Human-Computer Interaction (HCI), which provides guidelines for developing usable computer tools. However, the recognition of the complexity of the human information processing, together with the realisation of the importance of the context in which a computer system is to be put to use (see Kaptelinin in Nardi, 1996, pp. 104-107), has prompted researchers in this area to seek additional guidance from other fields. At the forefront of this endeavour, is the wish to expand on currently available systems design and evaluation methods by obtaining deeper insights into the ways and means in which humans use computers in their daily lives.

“One reason we need this expansion is that a key aspect of HCI studies must be to understand *things*; technology – physical objects that mediate activity....” (Nardi, 1996, p.14).

Much research has since been carried out to address problems relating to the usability of computer systems as evident in the prominence of usability testing during systems design. The focus on usability testing means that emphasis has been placed upon assessing the effectiveness of the computer systems in supporting the execution of actions at hand. This implies that assessment of the computer systems’ usefulness in assisting the user to achieve desired objectives is usually ignored. This situation has led to the strengthened need to “expand our horizons to think not only about *usable* systems, but also now *useful* systems” (Nardi, 1996, p.8). However, the prolific increase and dynamic nature of computer usage patterns has meant that developing a useful computer system has become more and more complex. Various researchers (Bannon and Bødker, 1991; Bannon, 1990; Gilmore, 1995; Norman, 1998) have made suggestions on how to rectify the situation having identified the problem of the usefulness of computer tools in assisting the user to achieve desired outcomes. As Johnson and Nardi (1996) observed, several factors affect the usefulness of a computer system. The misassumption that general design guidelines can be successfully applied to all situations disregard of the context to which the computer system is put into use has proved otherwise. It is difficult to introduce a single guideline to satisfy all requirements. The user’s judgement on the usefulness of a technology is usually influenced by their experience of its use in context. One of the main drawbacks to the introduction of effective systems design guidelines has been attributed to the lack of a unifying theory to guide research in this area (Kuutti in Nardi, 1996, p.24). Activity Theory (Nardi, 1996) has emerged as a suitable framework for analysing these HCI design issues in context.

1.2 Outline of Research Problem

However, many HCI practitioners have failed to benefit from this insight mainly due to the lack of established methods for operationalising concepts of Activity Theory

within the systems design process. Filling this *pragmatic vacuum* introduces a considerable number of challenges. To begin with, the use of theory to inform computer systems design requires the justification of the method applied to operationalise the theory, together with a provision of clear evidence of the mapping between theory and the design representation that is finally produced. This entails demonstrating the technological transferability of the method whilst adhering to the underlying theoretical framework. Furthermore, the recognition of the significance for Activity Theory to HCI research and practice implies that there is a growing recognition for the need to develop methods that operationalise these theoretical concepts for design purposes.

Therefore, the key research question that this thesis set out to investigate is:

How can Activity Theory be applied to HCI research and practice so as to inform systems design?

1.3 Research Approach

In order to address the outlined research question, this thesis took up the challenge of investigating the practicalities of using Activity Theory within HCI research and practice; thereafter to develop an Activity Theory based method for HCI design. The key idea was to use Activity Theory, not only as a descriptive tool for conceptualising user perspectives in context, but more importantly to empirically demonstrate the means by which concepts of Activity Theory could be holistically incorporated within HCI research and practice. Throughout this pursuit, two issues required careful and constant consideration. These issues relate to the technology transferability of the developed method and also the assessment of the extent to which the method adheres to fundamental concepts of the underlying theoretical framework. In other words, there were concerns relating to the correct interpretations and applications of Activity Theory concepts on the one hand. Whilst on the other hand, there was the need to develop a method that would fit in with the language and methodologies of HCI research and practice. In order to avoid

criticisms about the misinterpretation of underlying theoretical concepts, the construction of AODM was based on Engeström's expanded model of human activity - the activity triangle system (Engeström, 1987). Engeström's model was used to conceptually unify and represent concepts of Activity Theory that were considered relevant to work analysis and tool design. In this approach, concepts of Activity Theory are heuristically interpreted and applied in a manner that allows the development of a method to guide HCI research and practice. Whilst this thesis recognises the prominent use of Engeström's model in developmental studies of learning and working, it is more the recognition and acceptance of its perceived unification of concepts of Activity Theory that determined its use in this work.

In order to adhere to Activity Theory's emphasis on studying artefacts in their natural environment, the research employed a case study based approach to investigate the outlined research problem. The study used Activity Theory to analyse work practices in two organisations over a period of two years. These studies formed the basis for developing the Activity-Oriented Design Method (AODM) for HCI research and practice. AODM was developed in three phases whilst analysing work practices in the two case study organisations. The production of this method resulted from responding to emerging design and application issues whilst attempting to use Activity Theory to analyse work practices for computer system design purposes. A detailed illustration of this empirical work is reported in chapters four, five, six, and seven. These chapters include a systematic description of AODM's development and application procedure. It is assumed that the systematic description of AODM's development and application procedure makes the operationalisation process explicit. The construction of AODM constitutes the author's ideas about the application of concepts of Activity Theory in HCI research and practice.

1.4 Thesis Contributions

The main achievement of this thesis is the construction of the Activity-Oriented Design Method (AODM). AODM attempts to bring the richness of Activity Theory

to HCI research and practice. This method was developed to direct the application of a version of Activity Theory based on Engeström's (1987) conceptualisation so as to support requirements capture and data analysis processes of HCI design. AODM incorporates four methodological tools whose components and operational features are summarised as follows:

- 1) *Eight-Step-Model* developed to operationalise Engeström's model of human activity – the activity triangle system in terms of the situation being examined.
- 2) *Activity Notation* developed to aid system decomposition by breaking down a complex activity system into smaller manageable units or sub-systems.
 - a) *Three-operational-guidelines* were constructed so as to make the operational structure of the Activity Notation explicit.
- 3) The development of the technique of *generating research questions* based on the various components of the main activity system.
- 4) The development of a representational technique of *mapping operational processes* and relationships between sub-activity system components and identified contradictions.

AODM contributes to HCI research and practice by providing a theoretically and empirically grounded approach to support the processes of gathering, analysing and communicating early systems design requirements. This method is intended to help the designer to holistically comprehend the relational interactions and operational mechanisms of human beings' use of computer systems. In the meanwhile, this comprehension ought to be perceived from a social-cultural and developmental perspective in context. This broadened scope of HCI research and practice draws from developmental psychology ideas introduced by Vygotsky (1978) and Leont'ev

(1978). AODM extends the traditional cognitive focus by adding social-cultural psychological and contextual perspectives to the analysis of systems requirements.

Specifically, AODM is an Activity Theory derived method for analysing requirements oriented to examining the utility of a proposed or existing computer system rather than usability. The method is focused on supporting the analysis of utility arising out of complex work demands and contexts. Within the systems design and development process, AODM can be executed as part of the requirements elicitation process involving the study of work practices. This process would involve studying practices of the context or situation under investigation through observations and talking to targeted users of the proposed system including some of the stakeholders both in formal and informal settings. The output of AODM based analysis is a report outlining the Activity Theory based conceptualisation of work-based models and practices of the investigated situation. This kind of report is executed as part of the requirements specifications document hence forms a vital element of systems design.

1.5 Thesis Structure

Chapter two sets the scene for the rest of the thesis by investigating HCI perspectives on computer systems design. It begins by revisiting some the major historical events in computer systems design that influenced changes in systems design and application. This is followed by a critical review of various design methodologies, techniques and models currently used in HCI research and practice. Within these discussions, the chapter identifies key design challenges currently being addressed by HCI researchers and practitioners.

In chapter three, the thesis considers the use of Activity Theory to address the HCI design challenges identified in chapter two. In order to put these discussions into perspective, the chapter begins by introducing the Activity Theory framework. Here key points or areas in which Activity Theory seems to leverage HCI research and practice are identified and highlighted. These key points served as benchmarks when

conducting empirical studies described in later chapters. As part of the introduction, this chapter also discusses the historical background of Activity Theory, focusing mainly on the works of Vygotsky (1978) and also Leont'ev (1978; 1981). Thereafter, more modern perspectives on Activity Theory are reviewed by discussion Engeström's (1987; 1999) approach to Activity Theory with emphasis on the activity triangle model (Engeström, 1987). The chapter concludes by considering the benefits of using Activity Theory within HCI research and practice.

Chapter four considers the feasibility of using Activity Theory in HCI research and practice. Discussions in this chapter are mainly focused on establishing a suitable method for applying Activity Theory to HCI design. The chapter introduces the three phases involved in developing AODM tools. Detailed information about AODM's development and application procedure is presented in chapters five, six, and seven.

Chapter five presents phase 1 of the method development and application procedure. Discussions of in this chapter illustrate how Activity Theory was used to analyse work practices in the first case study organisation. The work reported in this chapter marks the beginning of empirical work carried out as part of this research. These studies provided an empirical grounding for the development of AODM by responding to emerging issues within the investigation. This study resulted in the production of the '*Eight-Step-Model*'.

Chapter six presents phase 2 of AODM development and application procedure. The chapter reports the analysis of work practices in the second organisation, which resulted in the incremental development of AODM tools. The study resulted in the production of the '*Activity Notation*' and also the *three-operational-guidelines*. Other AODM tools developed and discussed in this chapter includes the technique of '*generating research questions*', and, also the representational technique of *mapping operational processes*.

Chapter seven outlines phase 3 of AODM development and application procedure. This is the final phase of AODM development procedure. The work reported in this chapter results from a second analysis of work practices in the first organisation. The initial analysis of work practices in the same organisation is reported in chapter five. The purpose of this second study was to test the usability of AODM tools as a complete package. Chapter seven also marks the end of discussions about empirical work carried out as part of this research.

Chapter eight clarifies the contributions of this thesis to HCI research and practice. A complete description of AODM is given. Thereafter, some of the claims made about contributions of AODM to HCI design are validated using evidence from the case studies.

Chapter nine concludes discussions about the research work reported in this thesis. Shortcomings and limitations of AODM are identified and discussed. Finally, suggestions for possible areas of future research development are outlined.

Chapter Two

2. HCI Design Perspectives

The multi-disciplinary field of Human-Computer Interaction (HCI) is focused on ensuring the *usability* and *usefulness* of computer systems by providing guidelines, tools, and methods to inform the design process. Within this remit, the use of the term ‘HCI design,’ in this thesis encompasses the general creative processes of capturing, analysing, and communicating requirements for systems design. The adoption of this working definition of HCI design capitalises on the various aspects of multi-disciplinary HCI research and practice.

This chapter sets the scene for discussions in the rest of the thesis by reviewing literature on HCI design methods employed to ensure the usability and usefulness of computer systems. In order to show appreciation for the many years of research involved in the generation and accumulation of systems design methods, the chapter begins by reviewing the literature on historical developments in computer systems design. These discussions particularly focus on outlining some of the key events and contributors who influenced major developments in the design and application of computer systems (Baecker, Grudin, Buxton, and Greenberg, 1995; Shasha and Lazere, 1995; Pylyshyn, 1970). Hence the emergence of HCI research and practice. Whilst it is not practical for the purpose of this thesis to list each and every event and contributor, discussions in this chapter attempt to represent the most influential to the progression of systems design methods. Thereafter, the chapter moves on to consider some of the more recent and current HCI methods used in systems development. Within this theme, the chapter identifies key design challenges posed to the mission of developing usable and useful

computer systems. The response to these challenges is examined by critically analysing some of the design methods introduced to address the issues raised in the identified challenges. These discussions are summarised by considering design implications from the point of view of the requirements capture stage of HCI design. In conclusion, the chapter reflects on foregoing discussions to draw out current design issues being addressed by HCI researchers and practitioners. These design issues are explored further in chapter three of this thesis, which investigates how Activity Theory handles them.

2.1 Historical developments in HCI Design

During the early days of computing, computer systems were developed and predominantly used by specialists who wrote software programs to support their work. These specialists were experts who mainly worked in the engineering and scientific research fields. In the engineering and manufacturing sectors, the use of computer systems was motivated by their speed in processing data mainly to support routine and laborious calculations¹ including those performed in war efforts. Computer systems were used to organise and manipulate large amounts of data through the automation of repetitive human functions. “Humans excel at making judgements and planning complex actions, whereas machines are good at repetitive tasks” (Shneiderman, 1998).

Within the scientific research fields, there was a strong recognition of the need to communicate with each other so as to share expertise. This requirement is evident in Vannevar Bush’s (1945) seminal article “As We May Think,” in which he describes the increasing difficulties in managing and disseminating research results using the

¹ Notably, during the early 19th century, Charles Babbage’s (1864) insights on the design and implications of a self-sequencing calculating device – led to his invention of the ‘Analytical Engine’.

computer equipment of the day. Computer systems in those days were huge standalone mainframe systems that occupied the size of the whole house. Through his visionary insights of 'The MEMEX' device, Bush envisaged the extension of computer uses from data processing to information processing purposes. Describing his vision of a distributed MEMEX in which he outlined the possibility of building digital networked computers that incorporate multimedia functions and use of Compact Disc (CD), he foresaw the value of indexing and linking related data elements (information). Bush is widely recognised in the fields of HCI and Computer Science as the pioneer of hypertext² or hyperlinked information retrieval systems. Bush's visionary insights continued to inspire further developments in computer systems design and application. Some of these developments include Douglas Engelbart's (1963) invention of the 'Mouse' during the 1960s, also, Alan Kay's (1969) founding of, amongst other things, Personal Computers (PCs) and the Graphical User Interface (GUI). Engelbart³ was particularly interested in developing technology that would support asynchronous collaborations amongst geographically distributed workers. Engelbart held the view that the interface of a computer system was intimately linked to the work environment; therefore a computer system can serve as an excellent tool for facilitating work related collaborations. Alan Kay's most noteworthy contribution to the field of HCI and Computer Science can be attributed to the fact that he prompted the shift of paradigm by changing the way people perceive and use computers. Prior to this, computer users had to learn how to program or write software in order to use a computer. Through his work with children, Kay recognised the importance of allowing users to be able to interact

² The term 'Hypertext' was coined by Ted Nelson (1965), it refers to a system of linking related documents in a distributed networked system.

³ Engelbart began the Augmentation Research Centre (ARC) at Stanford Research Institute where he and his colleagues created the on-Line System (NLS). The NLS is recognised as the world's first implementation of the hypertext system (1963).

with computers in various ways other than text. In doing so, Kay initiated the representation of pictorial objects on a computer system's interface as a means for interacting with the computer. This was the introduction of the Graphical User Interface (GUI) - a metaphor that he further extended by developing the concept of object-orientation. Ben Shneiderman (1982) later coined the term 'Direct Manipulation' to refer to the process by which end-users interact directly with visible GUI objects on a computer system instead of textual programming syntax. Finally but not least, it could be argued that, to an extent, Bush's vision of a MEMEX has finally come to be realised in Tim Berners-Lee's invention of the World Wide Web (WWW) (Cailliau and Gillies, 2000). During the early 1990s, Tim Berners-Lee used the hypertext idea to create the WWW whilst working at CERN, the European Laboratory for Particle Physics (Berners-Lee; Fischetti, and Dertouzos, 1999). The WWW was originally developed to support collaborations and instant remote information sharing between physicists working in various institutions all over the world. However, major developments in networking and Internet based technologies have resulted in an amazing increase in the use of the WWW. Current use of the WWW has extended to supporting business processes, personal use, and connecting people across geographical boundaries and time zones.

Table: 1 shows a summary of some of the most influential contributors and inventions that led to various developments in the design and application of computer systems.

Name and Year	Invention	Area of Contribution
Charles Babbage (1864)	Analytical Engine	Data Processing
Vannevar Bush (1945)	THE MEMEX	Information Processing
Douglas Engelbart (1960)	Mouse	Collaboration and Organisational support
Alan Kay (1970)	Personal Computing (PCs)	Made computers usable by non-technical users e.g. children, general public.
	Graphical User Interfaces (GUI)	Introduced new ways of interacting computers i.e. GUI objects instead of text
Tim Berners-Lee (1989)	World Wide Web (WWW)	Supports worldwide instant remote information sharing

Table 1: Table of inventions

Summary of Design Developments

From the computer systems design point of view, advancements in the information storage capacity and processing speed of computer microchips meant that the physical size of a computer system has been reduced from a ‘house’ size mainframe to a ‘book-size’ laptop. Following further and more recent developments, the physical size of a computer system has shrunk to the size of, for example, a ‘palm-size’ personal digital assistance (PDA). Analogue and standalone systems have been replaced by digital networked systems that are faster with high information processing capabilities and storage capacity, therefore broadening the application areas prompting a move from data processing to information processing. These developments resulted in a gradual

extension of the computer user group from technical experts who are computer programmers to non-technical experts or novice users who cannot program.

2.2 Current HCI design methods

The increased use of computer systems by non-technical experts eventually led to a growing recognition of the difficulties experienced when using computer systems. As a result of this recognition, a new body of research - Human-Computer Interaction (HCI) emerged from what was previously known as the *man-machine interaction*⁴ to ensure the usability of computer systems (Dix, Finlay, Abowd and Beale, 1998). HCI practitioners have since committed themselves to providing design practices and methods to guide the development of usable and useful computer systems. This chapter will now critically review some of the design methods currently used to put into effect the outlined HCI remit. An outline of emerging design challenges will also be presented within these discussions. These discussions are not intended to be an exhaustive review of methods and techniques used in HCI design. Instead, the methods discussed in this chapter represent a selection of design issues that the author wishes to pursue further throughout this thesis. After discussing each Method (sections 2.2.1 to 2.2.11), design challenges and issues that emerge will be identified. These will be summarised and discussed in section 2.3.

⁴ The man-machine interaction research group was part of the Ergonomics Research Society of the 1940s (1949), which primarily focused on studying the physical aspects of human and machine interaction or what is now known as human factors (Dix et al., 1998.p.2). Human factors studies are concerned with discovering and applying information about human behaviour, abilities, limitations, and other characteristics to the design of computer systems so as to improve usability (promote effective human use) (Baecker et al, 1995.p.571).

2.2.1 The GOMS Model

A landmark contribution towards this effort is attributed to the works of Card, Moran and Newell (1983) for developing a cognitive model – GOMS for predicting user behaviour when interacting with a computer system. GOMS stands for Goals, Operators, Methods, and Selections rules. Systems designers normally use the GOMS model during task analysis to determine rules for selecting methods and operations that the user is likely to perform in order to achieve a goal. The development of the GOMS model is widely recognised in this field to represent an initial attempt to make qualitative research methods and experimental (quantitative) empirical results relevant to design. Prior to this innovative invention, there were uncertainties within the HCI community as to the contributions of what some referred to as ‘soft sciences’ (cognitive psychology) to systems design, since systems design mainly used ‘hard sciences’ (computer science) (See Newell and Card, 1985; also Baecker et al., 1995.p.578).

Despite its success, this groundbreaking effort has also attracted a lot of controversy regarding its practicality and effectiveness in informing the design of usable systems. See for example Carroll and Campbell (1986) who identified four faults with the GOMS model explaining that the model is too low level, limited in scope, arriving too late to influence design, and too difficult to apply. Others (Olson and Olson, 1991; Newell, 1990) have also identified shortcomings with the GOMS model and went on to make suggestions for improvement. Some of these shortcomings arise from the fact that the GOMS approach to design attempts to be highly predictive of user behaviour whilst assuming that this behaviour remains the same over the course of using the computer. However, it is difficult to accurately predict how the user is going to behave when interacting with a piece of software because human beings develop and use already

developed mental models⁵ (Gentner and Stevens, 1983) to help them understand new phenomenon. Mental models act as internal mental representations of actions and sequences of actions to be referred upon when interacting with a new tool. In the meanwhile, these mental models are not static; they are continuously developed and redeveloped during the course of action (Norman, 1983; 1986). Gentner and Stevens (1983) in their collected works on mental models of natural phenomena and devices also portray the evolutionary aspects of human mental models. They demonstrated that mental models and the mechanisms by which these models are constructed differ according to the task or problem domain.

Others (Olson and Olson, 1991) have also questioned the accuracy and reliability of using the GOMS model to predict user behaviour due to the fact that designers tend to make assumptions about the user's knowledge level and context of computer usage. As illustrated in the foregoing discussions about mental models, users' knowledge is complex because it draws from experience of using tools in similar situations. Given this stance, there are bound to be contextual influences from the environment of use, which could affect the user's judgements about the ease-of-use and usefulness of a computer system. Such judgements can also be influenced by opinions from peers on how a tool should be used.

In addition, the idea of predicting user behaviour for the purpose of informing the design of a computer system draws from the information processing approach to systems design (Kaptelinin in Nardi, 1996, pp104-107). The information processing approach perceives

⁵ Scottish psychologist Kenneth Craik, (1943), originally introduced the concept of 'mental models' to explain the constructs of mind. According to Craik, mental models are "small-scale models" of reality that the mind uses to anticipate events.

users as information processing units considered at the same level as machines. From a systems design point of view, this entails conceptualising the means by which users process information so as to generate ideas about how to control their actions. This conceptualisation is usually represented through the modelling and emulation of user-to-system information processes. However, research has shown that human beings do not process information in the same way as machines (Nardi, 1996).

“We have recognized that technology use is not a mechanical input-output relation between a person and a machine; a much richer depiction of the user’s situation is needed for design and evaluation (Nardi, 1996, Page 8).”

They draw from the social and cultural organisation of the context or environment in which tasks are carried out (Beyer and Holtzblatt, 1998).

Furthermore, human tasks are usually carried out in collaboration with others. Even in situations where a person works individually, their actions tend to feed into or affect other people’s actions in one way or another. An additional weakness of the GOMS model in this regard emerges as a result of its failure to adequately account for individual differences and group conflicts when making behavioural predictions. Being able to predict individual and group differences or contradictions would be useful particularly when designing computer systems to support collaborating users. On the positive side, the GOMS model is good at providing lower level descriptions of user behaviour. However, focusing on lower level performances means that the model ignores the broader work context and its role in constraining design.

Design Challenge: Need to account for evolutionary aspects of user tasks.

Whilst it is evident from the literature that extensive work has been and is still being carried out to apply, refine and broaden the GOMS approach to systems design (John and Kieras, 1996), the above review of the application of the GOMS model within HCI design has raised some challenging issues that merit further exploration within this thesis. Perhaps most compelling of these issues is the need to account for the evolutionary aspects of user behaviour. The assumption that user behaviour remains the same during the course of using a system is an oversight that requires rectifying. Changes in user behaviour can result in differences in interaction behaviour. In the meanwhile, differences in user behaviour could result in conflicts that cannot be easily recognised when making behavioural predictions.

2.2.2 Expert Approach

Other early HCI design methods utilised during systems design include what one would describe as the 'expert approach' to systems design. With this design approach, an expert or a systems analyst from the design team usually analyses the requirements for systems design. This entails gathering and interpreting information about the requirements for designing the proposed system. The expert is usually someone with good understanding of work practices of the possible field of application for the proposed system, for example, a heart surgeon in the case of a heart monitoring system. A systems analyst on the other hand could be someone with good working knowledge of the technical capabilities of the intended piece of software. This includes knowledge about the possible application areas for that software. The analyst draws from intuition and experience, and also follows some general design guidelines to formulate suitable requirements for the proposed system. This approach is not unusual since most early HCI procedures for assisting designers to achieve good computer usability had been

studied intuitively and empirically for many years (Preece and Kelley, 1995). Once the requirements for the design of a system have been gathered and analysed, they are then communicated to the systems developer who is usually a programmer. The programmer implements the outlined requirements into the interface features and operational functions of the system. However, the use of the expert approach to systems design presented HCI practitioners with different types of challenges. These challenges are discussed as follows.

Design Challenge: Need to reflect user input to design

One of the main disadvantages of using the expert approach to systems design emerges from the fact that end-users are generally left out of the systems development process. Users are not included or consulted during systems development. The general assumption is that users are not designers or experts on the capabilities of technology, they, therefore, have limited or no knowledge of what is possible (Gould and Lewis, 1983, p.51). This assumption makes it difficult to comprehend or appreciate the role that users could play in the design process, and also to imagine how that role can impact on systems design. As time went by, HCI practitioners and researchers began to recognise the importance of input from non-technical users into systems design (Grudin, 1990; Nielsen and Molich, 1990). There was a realisation that even though the analyst has expert knowledge about the capabilities of technology; it is the users themselves who know how they work in their own environment, although this knowledge may not always be explicit. In addition, even in situations where work processes are almost fully automated, there still tends to be some minimal amount of human input, for example to control the execution of functions. Therefore limited user input is incorporated into the systems development process mainly to enable the systems developer to obtain feedback on an already developed computer system. This usually happens in the final stages of

the system's development process during the evaluation stage so as to enable designers to obtain feedback on the usability of the system's interface.

2.2.3 Usability Testing

The term 'usability' testing has been loosely defined in literature but it is mainly used to refer to the process by which computer specialists come up with quantifiable categories for determining the 'ease-of-use' of a computer system's interface (Shackel, 1981). The process of determining the ease-of-use of a computer system is usually carried out towards the end of the development procedure during the evaluation stage (Preece et al., 1994). Traditionally, systems developers tend to use measurable engineering approaches and quantifiable categories to measure the usability of a system. This is referred to as usability engineering (Preece et al., 1994). By leaving usability testing right until the end of the systems development procedure, systems developers focus their attention on analysing the usability of the interface features, thereby, potentially ignoring other wider issues that stand to impinge on the usage and usefulness of a computer system. Usability evaluation of a computer system is therefore carried out to determine whether or not interface features and functionality meet the requirements set out by the expert or analyst (Bennett, 1984). This is accomplished by selecting certain usability categories from the initial set of system's requirements. These categories are then used as benchmarks to validate that the necessary interface features have been implemented and function satisfactorily, also to verify that the system that has been built is what the user wanted. The idea of selecting usability categories has been widely applied in various types of computer systems. For example, Shneiderman (1982) in his concepts of direct manipulation stipulates the usability requirements for a graphical user interface in terms of the following categorical features, which are also discussed in Preece et al. (1994, page150):

- Visibility of the objects of interest
- Incremental action at the interface with rapid feedback on all actions
- Reversibility of all actions, so that users are encouraged to explore without severe penalties
- Syntactic correctness of all actions, so that every user action is a legal operation
- Replacement of complex command languages with actions to manipulate directly the visible objects (and, hence, the name direct manipulation).

The problem with using quantifiable measures and categories to determine the usability of a computer system lies in the fact that, the expert selects the categories and also decides the considered levels of satisfaction. This design approach is therefore expert led. Users have no real input in the design process. Users are merely used as testers to confirm or refute the expert's expected results. The key argument against this approach is that, whilst the specialist has expert knowledge on the operations and capabilities of a piece of technology, it is the users themselves who understand the basics of how they work and use tools. In addition, methods employed to test the usability of a computer system can be driven by the design objectives of the systems developer. For example in controlled experiments, the designer can structure the usability evaluation tests in such a way that it enables him to obtain feedback on targeted design goals. This is particularly evident in situations where usability evaluation categories are selected and used as determinants for the usability of a computer system. Users are then required to rate these categories according to the designer's pre-selected parameters. A typical example is the use of a 'usability matrix' (Hix and Hartson, 1993) during systems evaluation.

On the other hand, one could argue that in uncontrolled usability experiments, the designer could leave it to the users to give unbiased feedback or opinion regarding the usability of a system. In such situations, contradictions may occur between the users'

objectives for taking part in usability testing and that of the developer. Developers seek to establish whether or not the system meets the already set design goals. Users on the other hand seek to establish whether or not the system is capable of helping them to efficiently carry out their duties. Establishing similarities and contradictions in these objectives ought to be an important part of the method used to guide the systems design process. The key point to note here is that there are much wider design issues about users (e.g. objectives when using the system, history, the social relations and psychological aspects of the user) that cannot be adequately addressed by usability testing. Furthermore, the depth and richness of the information gathered during usability testing is dependent on both the design objectives of the systems developer, users' issues and also the research method applied. The process of ensuring usability in the design of a computer system ought to be addressed from the intended user's perspective so as to enhance the usefulness of these tools in that particular context.

The whole idea of focusing on usability testing as a way of determining the effectiveness of a computer system is increasingly being questioned (Nardi, 1996; Norman, 1998). Nardi (1996, p.8) for example, calls for the need to "expand our horizons to think not only about *usable* systems but now *useful* systems." Norman (1998) a champion of the usefulness of 'everyday appliances' suggests the idea of 'information appliances' as a way of addressing the issue of the usefulness of computer systems. The basic argument against focusing on usability testing is that emphasis is placed on assessing the effectiveness of the computer system's ability to support the execution of actions at hand. For example, Howes (1995.p.101) defines usability in terms of 'learnability' where he refers to the amount of time it takes users to perform tasks and the number of slips or accidental mistakes that users make. Whilst the idea of assessing the physical and mental difficulty of carrying out a task is important from the ergonomics and human factors point of view, the usability approach tends to ignore issues related to the

usefulness of a computer system in assisting the user to achieve desired outcomes. We need to introduce design methods that will help designers to link user actions to the user's intended goals and objectives for carrying out that task in the first place. Another draw back to usability testing is that it is mainly carried out in the designer's work environment usually in laboratory settings instead of the user's normal work place where the system will eventually be deployed (Preece et al., 1995.P.650). This approach to testing the usability of a computer system fails to unveil the environmental constraints that may affect the use of a computer in the real situation. It is also difficult to capture the 'ecology' or history of the process of learning how to use the system, which may provide useful design insights for improving the usability and usefulness of the computer.

Design Challenge: Need to incorporate user involvement in design

Foregoing discussions have exemplified several challenging design issues that emerge as a result of focusing on usability testing during systems design. Most significant of these challenging issues is the lack of user involvement in the design process. Whilst the recognised need for user input was to an extent addressed through the introduction of usability testing, which enabled designers to at least incorporate minimal user opinions through feedback, it is apparent that users did not have real involvement in systems design. To borrow from Georges Perec's puzzle metaphor:

“...despite appearances, puzzling is not a solitary game; every move the puzzler makes, the puzzle-maker has made before; ... every blunder and every insight, each hope and each discouragement have all been designed, calculated, and decided by the other,” (Perec, 1992).

The above quote illustrates the presiding situation in HCI design prior to the realisation of the relevancy of involving users in the systems development process. Despite the many techniques introduced to solve computer usability problems, complaints about the difficulty in using computer systems persisted. There was recognition of the importance of involving users in systems design (Norman and Draper, 1986). This recognition led to the introduction of much more user-inclusive and user-focused systems design methods. Most of these user-focused methods come under the umbrella of the term ‘user centred design’. This chapter will now present a brief introduction of basic principles of the user centred design. Thereafter, other design methods that fall under the user centred design category will also be examined.

2.2.4 User Centred Design

The user centred design method (Norman and Draper, 1986) emphasises the inclusion of end-users throughout the systems development process. The focus on end-users implies that user opinion is highly valid when making design decisions. As a result of this, the process of iterative design is part and parcel of the user centred design method. Iterative design enables the designer to obtain continuous feedback from users throughout the systems development process. In order to obtain user feedback, early prototypes, mock-ups and technology immersion techniques such as the use of software simulations of the proposed systems are used to give the user a feel for the interface and functional aspects of the system. The feedback is used to reshape technology. The user centred design approach therefore aims to understand users and their tasks quite early into the system’s development process instead of leaving it to the end during the evaluation stage. Users are defined as potential real end-users of the system being developed, or their representatives.

One of the drawbacks of the user centred design approach lies in the fact that the method works well in situations where the end-user or potential users of the system being developed are clearly identified. Even though representative user groups can be engaged to play the role of 'real-users' in the design process, critics would argue that the kind of feedback that one obtains from this approach does not reflect real issues from the real situation. In addition, even in situations where the real users are involved in design, it can be difficult to decide on the appropriate number of users to join the design team. The size of user population involved in the design process has implications for the type of and richness of the information gathered. The larger the number of users involved the longer the design process is likely to take because the developer has to establish a common goal or mutual opinion on what is useful. In such situations, it can be difficult for the systems developer to obtain group consensus on what is useful so as to determine the type of interface features and functions to introduce in a particular system. On the other hand, the use of a small number of users to represent the whole population can yield less detail; whilst if the number of users is too large, information gathered can be general and less focused. This can cause problems in situations whereby the design task is focused on building a system for a specialised application area.

The user centred design approach also assumes that users being analysed have a collective view of what it is they are doing, what they are trying to achieve and why. Whilst this perception may be true to some extent, individuals working collaboratively or collectively can have varying motives that could affect the way they behave and carry out work activities (Nardi, 1996). These individual motives or objectives are not always explicit to fellow workers. The motives reflects the group various perspectives of work activity.

A further problem, in common with previous approaches, is that although user centred design is focused on the user, the general tendency had been to carry out the systems design and usability evaluations at the developer's workplace in laboratory settings away from the intended context of use – the user's workplace (Beyer and Holtzblatt, 1998). It is difficult to obtain a good understanding of the users' work practices and also to test the usefulness of a tool when tests are carried out in a different environment to that of intended application.

Gould and Lewis (1985) outline three basic principles of the user centred design method, which are also discussed in Preece et al., (1994.p.343) as follows:-

- 1) To focus on users and their tasks early in the design process, including user guides, help and ensuring that users' cognitive, social and attitudinal characteristics are understood and accommodated.
- 2) To measure reactions by using prototype manuals, interfaces and other simulations of the system.
- 3) To design iteratively because designers, no matter how good they are, cannot get it right the first few times.

The above basic principles of user centred design have since been interpreted and applied in various ways by HCI design practitioners. Whilst several issues determine the means by which principles of user centred design are applied, e.g. context of design project, size of user population, duration of project, rules and regulations, etc; user centred design has evolved to incorporate almost all design methods that focus on the user during systems development (Preece et al., 1994.p.343). This chapter will now discuss some of these user centred design methods in relation to their effectiveness in ensuring the usability and usefulness of a computer system.

2.2.5 Participatory Design

Participatory design (Schuler and Namioka, 1993) is a work-oriented approach that considers potential users of the proposed system as equal partners or co-designers in the systems development process. Equal partnership in this sense implies that users have equal status, roles and responsibilities within the systems development process at almost the same level as systems developers, and other stakeholders within the design team. Sometimes referred to as cooperative design (Greenbaum and Kyng, 1991), the participatory design method originates from the Scandinavian countries. It emerged as a result of employee influences through trade unions that resulted in collaborations between workers and management in organisations. This collaboration prompted the generation of new methods for developing new technologies for use in the workplace. The cooperative design methods attempts to capture complex and messy issues of the workplace so as to improve the design of a computer system that supports these activities. The underlying premise is to maximise user involvement in the systems design by giving users equal responsibilities and treating them as equal participants in the systems development process. Therefore, this approach makes users equally accountable for the design decisions made about the system being built.

However, critics of the participatory design method have questioned the merits of treating users as equal partners in the design process. They argue that users do not know enough to be equal partners, but they can instead be informants (Scaife and Rogers, 1997 and 1999) in the design process, to be consulted as and when required. Others have also voiced their concerns about the idea of treating users as equal partners in the design process (Druin, 1999). For example, in discussions of designing software for children Druin (1999) points to differences in power structures within the design team as one disadvantage of treating users as equal participants. She further explains that some

of the ideas that users (especially if they are children) come up with may not be workable in computational terms. Therefore even though users may come up with several smart ideas about the design of a software product, it is the systems developer who makes the final decision as to what gets implemented into the system and what gets left out.

On the plus side, participatory design methods enable the design process to benefit from the expertise and experience of workers in the intended application domain. However, the idea of treating users as co-designers or equal partners demands full-time involvement in the systems development process. As Bødker, Grønbaek, and Kyng (1995) noted, “full participation from the users requires training and active cooperation, not just token representation in meetings or on committees.” It therefore can be difficult to find users who are willing to give full-time commitment to a design project, since users tend to have other duties to carry out. The idea of training may also put a lot of intellectual demands on users as participants in the design team. This may not go well with some users. In addition, participatory design methods require users to sketch out their ideas in brainstorming sessions. This design activity may prove to be intellectually taxing for some participants. Participatory design method therefore physically or mentally takes the users out of the social context of their normal work situation because most design projects are carried out at the systems developer’s workplace in laboratory settings. Research has shown that excluding people from their normal work environment changes their patterns of behaviour (Suchman, 1987). Arguing for the ‘situated action’ approach to understanding work practices, Suchman (1987) illustrates that taking a worker away from the workplace changes the very nature of the worker’s actions. Real action is *situated action*; which occurs in interactions with the materials tools (e.g. computers) and people of the workplace (social aspects).

2.2.6 Informant Design

Debate surrounding the role of users within the systems design process seems to be resolved in the introduction of the informant design method (Scaife, Rogers, Aldrich and Davies, 1997). The informant design method attempts to clarify the role of users in systems design by emphasising the fact that users are not designers, but can be involved in the design process at any stage, as informants (Scaife and Rogers, 2001). The informant design approach therefore requires that users are brought into the design process for a purpose, as and when their expertise is required. In practice, this entails identifying and understanding the nature of relationships and interactions that exist between members of the design team (including users as informants) so as to decide how and when to effectively involve each member into the design process.

“Specifying an effective method for involving different people in the design process at different stages is what we have done with our ‘informant design’ framework. Essentially, this involves determining the different phases of design, identifying who will be the informants in these, what their inputs will be and what methods will be used. Our emphasis is to view different people as informants, through our interaction with them” (Scaife et al., 1997).

Thereafter, the design team needs to establish how the various sources of contribution to the design task can be brought together in relation to the objectives of the project under development. For the designer, such a flexible approach to user involvement can also raise concerns regarding how to access user expertise and also uncertainties as to the level at which to gather that insight. In order to address these concerns, the informant design approach employs various levels of prototyping so as to blend different methods of eliciting user expertise, for example, through the use of ‘low-tech’ and ‘hi-tech’ prototyping materials (Scaife and Rogers, 2001). Low-tech prototyping materials mainly refer to ‘lightweight’ communication and creative tools that the user is already

familiar with and confident to use. These include, for example, coloured pens, scissors and paper cardboards from which models of interface features and objects are developed (Scaife and Rogers, 2001). Hi-tech prototyping materials on the other hand, include more sophisticated communication and creative tools, for example software based prototyping tools, simulators and virtual reality systems. Designers use hi-tech prototyping materials mainly during later stages of the systems design process to test or demonstrate the functionality of the system to potential users. The idea of using low-tech and hi-tech materials to support prototyping is not unique to the informant design approach. However, one of the key advantage of its incorporation within informant design emerge from the fact that designers are required to plan or establish in advance the effectiveness of using these techniques to support prototyping. This means that designers need to have a clear understanding about the kind of data to be acquired, and also determine possible contributions to be input into the design process. The informant design approach therefore uses low-tech and hi-tech prototyping materials to support targeted and focused information gathering.

When compared to both the user-centred design and participatory design methods, the informant design approach takes the middle ground. Whilst informants design embraces the user-centred design idea of involving users in the design process, users are not perceived or treated as ‘reactive critics because it is assumed that users have motivations and expectations that designers cannot intuitively know (Scaife et al., 1997). Moreover, informant design is agreeable with the participatory design idea of giving users a more active role or to have input into the design process; however, instead of giving users full responsibilities on the design task, the informant design approach seeks user opinion on specific design issues. Therefore informant design does not unnecessarily overburden users with design responsibilities and a prolonged commitment to the design process, which appears to be the case with the participatory design method. The informant

design approach therefore seems to offer a balanced compromise between accounting for user opinions and involving users in the systems design process.

However, in order for users to become effective informants in the design process, clear information about the design problem and possible design solutions, including what is technologically possible to implement need be provided. This kind of information is necessary to ensure ‘informed participation’ (Fischer, 2000) on the part of the user. Having said that, design problems relating to the usefulness of a computer system together with possible solutions may not always be immediately apparent to either the designer or users. Such information tends to emerge once the system is in use. At the same time, even though users may be more knowledgeable about their work and environment of practice, users are not always the best commentators of what they do. Therefore, the design task of getting the right information from users at the right time can prove to be a major challenge for the system designer. The predicament for the designer is to establish the best way and right time to elicit that information from the informant user.

Design Challenge: Need to focus on usefulness

Even though some of the methods discussed so far seem to be vying against each other on matters of application and focus, overall, methods that focus on user involvement have made major contributions to the HCI design effort of ensuring systems usability. However, the success of usability focused design methods has meant that new design challenges are emerging. These emerging challenges raise issues relating to the ‘usefulness’ of computer systems or ‘fitness for the purpose to which a system is put to use’ (Norman and Draper, 1986). Issues relating to the usefulness of a computer system have increasingly become important as more and more people have begun to use

computers in every day activities. There is an acknowledged user need to be able to use computers in similar ways to any other tool to help them achieve desired goals (Nardi, 1996). This acknowledgement implies that usability prediction theories, for example, *Fitts' Law*⁶ (Fitts, 1954) are no longer sufficient for the emerging design challenges that focus on the usefulness of a computer system. These design challenges are prompting HCI practitioners and researchers to investigate new ways of ensuring that computers support users in ways that make sense to them. This chapter will now explore some of the design methods introduced to respond to the design challenge of ensuring the usefulness of computer systems.

2.2.7 End-user Programming

Amongst some of the approaches introduced to ensure the usefulness of computer systems is the 'end-user programming' development Method (Cypher, 1993). With end-user programming, the user is provided with an ease-to-use programming environment that incorporates a collection of tools. These tools can be assembled and customised by the user to suit the task at hand. The basic idea behind end-user programming is to allow users with no or limited programming skills to create new applications by re-assembling interface tools according to desired use. The end-user therefore, still requires basic programming skills to be able to assemble and use these tools efficiently (Nardi, 1993). The end-user design method therefore tends to be successful in situations where users have a good mix of basic software development skills and knowledge of the application domain. Given this perspective, end-user programming tools can be very successful in providing users with a flexible means of interacting with their work

⁶ *Fitts' Law* has been applied mainly to assess constraints on the motor system when using a computer system so as to predict the amount of effort and time it takes the user to move an object e.g. mouse from one part of the system's interface to another. See for example, Card, Mackinlay and Roberts (1990), used Fitts' Law to predict the usability of various mouse designs.

environments (Nardi, 1993). However, even though end-users are given flexible control over tool usage, they usually have no say or role in the actual development process of the underlying software or infrastructure that incorporates these tools. The end-users' first experience of interacting or using these computer tools happens once a system is delivered. As a result of this, the design of end-user programming tools is often based on preconceptions about the tasks and workflow of user domains that the systems developer is familiar with. Therefore, even in situations whereby the user has basic programming skills and good understanding of the task at hand, he is still faced with the problem of unravelling someone else's design inferences so as to efficiently assemble and use the tools presented.

Another drawback to the end-user programming design approach results from the fact that systems developers' tend to have a generalised view of the applications areas for end-user programming tools (Nardi, 1993). The end-user programming paradigm attempts to meet the needs of diverse users by producing standard programs that incorporate various application features. Consequently, most end-user tools fail to adequately support specialised user communities due to rigid infrastructures of the underlying software. However, end-user systems developers have since recognised these user concerns and introduced some measures to rectify this situation. The introduction of task-specific programming languages such as spreadsheets, and also the introduction of domain specific end-user programming environments such as Computer Aided Designs (CAD), both of which integrate standard application libraries were targeted towards resolving this very issue (Nardi, 1993). The introduction of CAD tools as part of the end-user programming environment emerged as a result of the recognition of the need to support specialised user tasks, and also to accommodate differences that exist in various application domains by introducing tools that operate across application boundaries. However, these design efforts still present the user with standard solutions.

The paradox is that the design mechanisms for these end-user programming tools still utilise general design guidelines that are not tailored to any specific application domain. Several HCI researchers (Gilmore, 1995; Orlikowski, 1992) have questioned the effectiveness of using general guidelines to direct systems design. As Johnson and Nardi (1996) observed, several factors affect the usability and usefulness of a computer system. It is difficult to introduce a single guideline to satisfy all possibilities as the user's judgement on the usability and usefulness of a computer system is usually influenced by their experience of its use in context.

Design Challenge: Need to understand the user and context of use

Foregoing discussions have exemplified some of the emerging issues following the examination of some of the HCI design methods introduced to ensure the usefulness of computer systems. Whilst a lot of progress has been made towards this effort, there are other design challenges associated with the usefulness of a computer system, which are not adequately addressed within the discussed methods. These challenges highlight the need to understand the way the intended user of the system operates, and also the context in which the user operates. The HCI community acknowledges the importance of addressing these user perspectives as part of the design process. It is generally agreed that a better understanding of how people work could help in producing better tools to support human tasks (Nardi, 1996, page 8). HCI researchers and practitioners have since committed themselves to this cause by continuously exploring, developing and refining new design methods to understand the computer tool user and context of use. Discussions in this chapter will now consider some of the HCI design methods focused on understanding the user and the context of use for the computer system being developed.

2.2.8 Ethnography

Ethnographical methods represent one of the earliest ways of gathering information about users and their tasks in their natural environment (Hughes, King, Rodden, and Anderson, 1995). Traditionally, the use of ethnographic methods had been confined to the fields of anthropology. Attempts to adapt ethnographic methods to HCI design began in the 1980s following the realisation of the socially situated nature of human-machine (computer) interaction (Suchman, 1987). HCI researchers and practitioners had realised that the idea of analysing individuals interacting with computers gave a narrow focus on understanding user and computer interactions. In addition, there was a growing awareness and acceptance that human information processing mechanisms are complex and cannot be recreated in a computational device since they are influenced by the social and cultural context in which human interactions occur (Monk and Gilbert 1995). It was thought by some that ethnography could provide the intellectual and analytical power needed to develop broader, socially informed views on the relationship between humans and computers. Prior to this, HCI design had focused on laboratory experimental assessments of individual performances on isolated tasks as a means for testing the usability of selected interface features.

The use of ethnographic methods requires that the researcher immerse himself or herself in the local culture of the people for an extended period of time. During this time the researcher participates in local activities, listens and asks questions (Hammersley and Atkinson, 1995). This prolonged period of research enables the researcher to study work practices and the cultural organisation of a particular activity in its natural environment. Even though ethnographic methods are suitable for HCI design, the emphasis on a prolonged period of research makes it less practical for most design projects timescales. Most products have short development life cycle. Whilst an ethnographer's role would

be to participate in people's daily lives for an extended period of time, watching, listening and asking questions, a systems developer on the other hand needs to limit this process to a period of days or even hours, but still to obtain relevant data to inform the design process. Therefore, there is a need for a method that can be used on time whilst capturing the richness of the origins and social context of the gathered design requirements.

There are, however, many methodological challenges with regards to incorporating ethnography into HCI design. Even though several researchers have used ethnographic methods to guide systems design, it is difficult to find a well-documented method for incorporating these techniques into systems design (Blomberg, et al., 1993; Hughes et al., 1995). There is not yet a documented method on how to observe people or how to gather systems requirements using ethnographic methods. The lack of a documented method for applying ethnographic approaches extends to the difficulty in interpreting the detailed qualitative data that is usually gathered. "It is not yet clear how their (ethnographers) approach can contribute to the design of new systems (Dix et al., 1998.p.543)."

2.2.9 Contextual Design

Current emphasis in HCI design to understand the users' work practices in the environment in which work is carried out has led to the introduction of more context aware design methods. Contextual Design (Beyer and Holtzblatt, 1998) is one such method. The contextual design method for gathering systems requirements attempt to understand users' tasks, roles and work environment by observing users whilst they carry out their duties in context. The basic principle is that the designer observes users at work so as to understand work practices and identify problems. Thereafter, the designer tries to envision possible design solutions to the observed work situation.

These possible design solutions are then discussed in consultation with users so as to obtain a shared understanding of users' work, and also to discuss the systems design options available to support those work practices. Note taking, drawing, audio and video recording of conversations techniques are utilised to aid the data gathering process. The information gathered is then collectively analysed by the design team, which includes users, to identify repetitive and conflicting patterns in work activity. This information is then used to formulate design decisions and suggestions represented through the use of mock-ups, scenarios, etc. These design representations are then implemented into the computer system being developed to support work activity within that context. The contextual design method therefore incorporates aspects of both participatory design and informant design as evident in consultations with the user during the design process (Holzblatt and Jones, 1993). However, one of the main differences between the participatory design and contextual design is that, contextual design requires the designer to collect data in the users' work environment. In comparison with traditional ethnographic methods, the contextual design methods of research attempt to cut down on time for gathering user information by allowing the designer to explore design alternatives whilst observing users performing typical activities. This way, researchers can ask questions for clarification where needed. However, it can also be difficult to obtain the desired input to the design process by asking questions whilst users are busy carrying out their duties.

2.2.10 Soft Systems Methodology

Another widely used systems design method within HCI is the Soft Systems Methodology (SSM). SSM has been incrementally developed by Peter Checkland (1999) since the 1970s. The method helps designers to understand human actions and work situations in a much wider context as an essential aspect of the systems development process. Developed from Checkland's 'Systems Theory', SSM takes a

broader perspective on understanding work organisation by viewing it as a system in which both the technology-in-use and the people carrying out tasks are considered to be essential components that make up the system. The notion of 'system' in this context understandably embraces the 'wholeness' of the various elements of the situation or work activity. From this perspective, the SSM design approach seems to treat users as equal components of a system. Nevertheless, design methods based on the information-processing paradigm of treating users as equal components that make up a system have been widely criticised elsewhere (Nardi, 1996).

The process of applying SSM to a systems design task involves the construction of a 'real-world' and 'conceptual' representation of the problem situation or system being examined. The real-world view involves the identification of the problem, followed by the production of a detailed description of the problem using a '*rich picture*'. In this context, a 'rich-picture' incorporates all components and processes of the real-world system, for example, stakeholders, tasks, organisational structure etc. Various data gathering techniques are used to obtain this general information so as to build a rich picture. These include but are not limited to questionnaires, interviews, brainstorming, workshop activities, role-play, simulations etc. The main idea here is to use less structured and informal techniques so as not to restrict the description. Both intended users of the system being developed, and the systems designers, are involved in this process of producing a rich picture. There is no standard style for producing a rich picture. Any style is acceptable as long as it is clear and informative to the designer.

Once a rich picture of the real-world is produced, the design team, which includes users and other stake holders, then moves on to develop a 'conceptual-world' or conceptual representation of the real world (system) as they understand it. The point to note here is that, whilst the production of the real-world model can be carried out in the real situation

or environment in which work is carried out, the process of developing a conceptual-world is conducted away from the real work situation. This is so to prevent potential influences from the real world that may prejudice the description of the conceptual-world. The actual process of developing the shared conceptual-world involves the description of the system from the point of view of the various stakeholders. This is referred to as the identification of the *root definition* of the system. The ‘root definition’ itself is described in terms of the *CATWOE*, an acronym for the various elements of a ‘root definition’ of a particular system. Checkland (1999, pp.223-227) explains the various elements of the CATWOE as follows:

<i>Customers</i>	Those who stand to lose or benefit from the system being built.
<i>Actors</i>	Those who carry out the main activities within the system
<i>Transformations</i>	Changes that affect the system. Analysis of the means by which defined inputs are transformed into defined outputs.
<i>Weltanschauung</i>	Descriptions of how a system is perceived from the point of view of a particular <i>root definition</i> .
<i>Owners</i>	Those who commission the system.
<i>Environment</i>	Considers constraints from the ‘world’ in which the system operates.

Table 2: Shows the various components of the CATWOE (Checkland, 1999)

Once the root definition has been developed, then the conceptual model is formulated and compared with the real system so as to identify discrepancies. The conceptual model defines what the system has to do to fulfil the root definitions. Discrepancies

help to identify transformations and changes that are necessary to match the two perspectives of the system in an iterative process. Thereafter decisions on the type of actions to be taken can be made. However, even though the SSM helps the designer to identify and conceptualise the various cognitive processes that make up work activity within a system, it is difficult to establish the relationships that exist between the various perspectives. This could be attributed to lack of common focus in the conceptual description of the system amongst participants. In such cases, an initial establishment of a common focus amongst all stakeholders or participants can help to translate the identified discrepancies in terms of how they relate and affect each other.

The SSM is therefore focused on producing a shared understanding of the systems by identifying discrepancies between the description of the ‘ideal’ system and the ‘real system’. It offers a flexible approach to tackling real world problems by supporting detailed abstraction of the design problem in context. However, others (Dix et al., 1998.p.229) have raised concerns about the ease of use of this method. In order to be successful, the application of this method requires a lot of practice and user commitment to the design task.

2.2.11 Activity Checklist

Increased awareness of the importance of understanding the user and context of use has resulted in the introduction of several approaches targeted towards this effort. The *activity checklist* (Kaptelinin, Nardi, and Macaulay, 1999) is one such approach. Kaptelinin et al., (1999) developed the activity checklist from the ‘activity theory’⁷ framework as a tool for helping designers to organise and use contextual information.

⁷ The Activity Theory framework is introduced and discussed in detail in chapter 3.

The activity checklist provides tools to help the designer to understand the context of use for the proposed system. The notion of ‘understanding the context of use’ in activity theory implies conceptualising both the material and ideal conditions of computer use.

In terms of application, the activity checklist is presented in paper form and outlines key elements or fundamental principles of the underlying framework. These fundamental principles are organised in a table and presented with sample questions to aid data gathering. However, activity theory is a very complex framework, which can be very difficult to understand let alone to apply. Due to the complexity of the framework, the checklist incorporates a basic introduction to the presented fundamental principles. The idea of having to learn the basics of a complex underlying theoretical framework before using the checklist may discourage some systems designers from using the checklist. In addition, there is no clear mapping between the sample questions presented in the activity checklist table and the presented fundamental principles of the theoretical framework. It is therefore, difficult to visualise the theory within these sample questions. Therefore critics could argue that such questions can easily be generated intuitively without having to endure the cognitive torture of learning the basics of a complex theoretical framework. According to the authors, the checklist is best used as an aide mémoire when reviewing field material or when preparing for an ethnographic type session in the field. There is no prescribed formal or structured method for using the activity checklist. The designer or researcher is encouraged to use the checklist in conjunction with other design methods as and when required.

The next section will put foregoing discussions into perspective by reviewing the relationship between HCI methods and the requirements capture process of computer systems design. Thereafter, a concluding summary of key design issues raised about HCI design methods including posed challenges is presented.

2.3 Summary - HCI Methods and Requirements Capture

The key professional task of a systems designer is to draw out requirements for systems development. Requirements capture in this context entails gathering, analysing and communicating information about user needs, user tasks and the context of deployment for the proposed system. To this effect, several HCI design methods have been introduced to guide systems design at requirements capture stage. This chapter has reviewed literature on some of the methods used in HCI research and practice to support the systems design. The review of literature about current HCI design methods has led to the identification of certain limitations that merit further exploration in this thesis. These methodological limitations present challenges to HCI research and practice. This chapter will now discuss and summarise some of the key design issues that emerge from the identified challenges.

- **Challenge:** *Need to account for evolutionary aspects of user needs and tasks*

As evident in the foregoing discussions in this chapter, HCI practitioners currently recognise that user requirements and user tasks are not static, they evolve and change over a period of time. This recognition has resulted in an increased awareness of the need to account for the evolutionary or transitional aspects of these user perspectives. Within this evolutionary sphere, there tend to be variations in user needs and user tasks that usually emerge as a result of *differences in individual and group motives* for performing tasks. These differences sometimes manifest themselves in conflicts. Conflicts in user needs or tasks are usually dependent on the background and social setting of the cultural context in which tasks are carried out. These challenges can also change from time to time. Producing design methods that help to address constantly changing problem contexts is the challenge for HCI design. The

complexity in design emerges from the need to synthesize the various differing perspectives of the problem. Some of the design issues that emerge from these considerations raise the following questions for HCI design:

Design issues raised:

- How to conceptualise the developments and changes that occur in user tasks and requirements?
- How to differentiate between basic and advanced interactions when analysing user tasks?
- How to conceptualise relational differences and similarities that exist *within* and *between* user interactions at various levels of operation?

- **Challenge:** *Need to reflect user input in design*

The need to incorporate user input in systems design was recognised to be important mainly for the purpose of obtaining user feedback on the systems built. This realisation meant that new approaches for gathering and analysing systems requirements were required. Whilst the thesis has examined and discussed some of the methods introduced to respond to this challenge, there still exist a number of design considerations to address in this regard. These considerations raise the following design issues:

Design issues raised:

- How to identify the relevant user interactions to focus on?
- What sort of data to gather about potential users of the proposed system and their tasks e.g. should the designer include the study of the psychological aspects of the user and tool use?
- How to gather data about user tasks, needs, and, also their knowledge about using the system?

- **Challenge:** *Need to incorporate user involvement in design*

The recognition of the need to involve users in systems design represents a move from treating users solely as systems testers in usability evaluation exercises so that the developer can validate and verify the usability of a system. It was realised that feedback from usability evaluation sessions carried out towards the end of the systems development process failed to reveal all the problems that users may experience when using a computer system. Difficulties in the usability of a computer system ought to be perceived from the users' perspective. Systems developers realised the importance of involving users in design for much longer periods. This design approach gave users more input in the design decisions made about the system being built. However, this important step also raises new design concerns for the systems developer. For example, a decision has to be made regarding the level of contribution to be expected from users. There is also a need to consider whether to give users equal say and responsibilities as experts in the system's development process. The paradox in this regard is that designers have the technical expertise about the capabilities of the proposed system, whilst users have

the knowledge about the operational structure of the domain of application. In addition to these concerns, the design team also needs to consider whether to treat users as full-time members of the design team, or as consultants in the system's development process. These emerging design issues are summarised as follows:

Design issues raised:

- How to define the user group (whether to work with a single user who is a domain expert or multiple users)?
- The designer needs to consider the level of contribution to be expected from users. For example decide whether users will be involved on a full-time basis as part of the design team, or on a part-time basis as consultants in the system's development process?
- There is a need to establish how much power to give users during systems design. Establish who has the final say on what gets implemented into the system?

- **Challenge:** *Need to focus on usefulness*

There currently exists a recognised shift in HCI design emphasis from focusing on interface usability issues of a computer system, to beginning to address issues relating to the usefulness of a computer system for the purpose to which it is put to use (Nardi, 1996; Kellogg, Lewis and Polson, 2000). Whilst most of the methods discussed in this chapter go a long way towards facilitating this process, there still remain certain challenges that must be addressed if these methods are to be successfully utilised to satisfy the emerging HCI design focus. The identified HCI challenge to produce useful systems raise the following design issues.

Design issues raised:

- How to make research findings bare on design (i.e. how to communicate findings to systems developers)?
- How to test the usefulness of the system?
- How to interpret data gathered about user tasks, and also how to validate design representations so as to produce a useful systems?

- **Challenge:** *Need to understand the user and context of use*

Understanding the usefulness of a computer system entails understanding the context of deployment for that system. The identified HCI challenge relating to the need to understand the user and context of use raise the following design issues.

Design issues raised:

- How to account for the work culture and organisation of the context of deployment for the system being built?
- How to handle variations in the objectives of stakeholders (users, system designers etc) on the design team?
- How to account for variations in work patterns of collaborating potential users of a computer system?

2.4 Conclusion

In the last two decades (since the 1980s), the HCI field has acquired a great deal of insight into the computational aspects of systems design, which has resulted in the development of reasonably usable computer systems. However, these important contributions are not without pitfalls. There is a recognised need to expand on this effort by shifting design emphasis away from the computer interface as the focal point to begin to address issues relating to the usefulness of computer systems (Kellogg, Lewis and Polson, 2000). This entails developing design methods that enable the gathering and analysis of requirements that result in the development of useful systems. In order to produce requirements that result in the development of useful systems, the designer must understand user issues from various perspectives. This implies the adoption of a broader view of HCI design to reflect the field's evolution towards more complex and more contextualised views of systems design and use (Beyer and Holtzblatt, 1998).

The kinds of design methods that are required are the ones that enable the designer to conceptualise multiple views of stakeholders (users + members of the design team) within that design task. The aim is to obtain a shared understanding about the user, the design task, and, the activity to be supported. It is therefore important that this conceptualisation does not impose strict divisions between these perspectives. The current challenge is therefore to rethink HCI design in a much broader context. The HCI community needs to engage in producing design methods that are holistically bounded (Star, 1989) with capabilities to reflect on the various perspectives of user issues. There is a need to account for both the generalizability and specialisation of design efforts, and to account for socially constructed practices over time. Within this holistically bounded framework, the relevant theories for guiding HCI design are those that focus on social-cultural, developmental, relational, and contextual themes. The task of addressing these

themes is not without difficult. Some of these themes incorporate inherently ill structured and ill-defined perspectives that must be handled by the design method (Star, 1989). The challenge for the designer is to understand user interactions, and requirements from these perspectives. There is therefore a need to develop design methods that will offer the designer a broader perspective on HCI design.

In the current design situation, use relations have become the focus of the design task. These concerns are currently receiving a lot of attention in HCI design and practice (Kellogg et al., 2000). Several paradigms and theories are being put forward to contribute to this effort. One such theory is Activity Theory (Nardi, 1996). The thesis will explore these challenges and raised design issues further in the next chapter by investigating how Activity Theory handles them.

Chapter Three

3. HCI Design and Activity Theory

In the previous chapter (chapter two), some of the methods used to inform HCI design were examined. This investigation highlighted some of the design concerns that HCI researchers and practitioners are currently struggling with in an effort to ensure the development of *usable* and *useful* computer systems. This chapter continues this investigation, by examining how Activity Theory, as an alternative framework for informing HCI design (Kuutti in Nardi, 1996, page 17), handles the design issues raised.

This chapter begins by presenting a brief overview of the situation in HCI, which led to the consideration of using Activity Theory ideas in HCI research and practice. In order to put these discussions into perspective, the section that follows explores the historical context for the development of Activity Theory. Here the chapter begins by reviewing the literature on writings of Vygotsky (1929/1978 and 1930/1981) and Leont'ev (1978, 1981). This is followed by an examination of some of the more recent expansions and exploitations of Activity Theory ideas as exemplified in the works of Engeström (1978, 1999). Thereafter, the chapter discusses some of the fundamental principles or 'basic principles of Activity Theory' as explicated by Kaptelinin (1996), and also Cole (1996). Given that the main objective of this thesis is to establish how Activity Theory can be used to leverage HCI research and practice (see chapter one), possible areas in which Activity Theory can enhance and contribute to HCI design are outlined in the next section. Finally, this chapter revisits HCI challenges identified in the previous chapter so as to produce an Activity Theory based response to the design issues raised.

HCI practitioners have long striven to introduce design methods and guidelines that enhance the *usability* and *usefulness* of computer systems (Gilmore, 1995; Norman,

1998). In addition, the complexity of human information processing, which draws from social and cultural issues in the environment has prompted researchers in this area to seek additional guidance from other fields (Bannon, 1990b; Bannon & Bødker, 1991; Kuutti, 1996). This, together with the realisation of the importance of the context (Beyer and Holtzblatt, 1998) into which a computer system is to be put to use (Suchman, 1987), has led to an increased interest in using Activity Theory within HCI research and practice (Nardi, 1996). But what is Activity Theory?

3.1 Activity Theory – a brief introduction

Activity Theory or the ‘cultural-historical theory of activity’ (its full name) is an inter-disciplinary philosophical framework for studying both individual and social aspects of human behaviour (Engeström, 1999, page 19; Cole, 1996, pp.104-105). Kuutti (1996) gives the following introduction to Activity Theory:

“Activity theory is a philosophical and cross-disciplinary framework for studying different forms of human practices as developmental processes, with both individual and social levels interlinked at the same time” (Kuutti in Nardi, 1996, page 25).

Activity Theory as commonly used within the HCI community is not a fully developed theory, but a framework from which several ideas, theories and methods for conceptualising human practices (activity) in relation to computers could emerge. Within this framework, human activity or ‘what people do’ represents the basic unit of analysis when studying human behaviour. Activity Theory is therefore, committed to understanding both individual and collective aspects of human practices from a cultural and historical perspective. It achieves this by presenting a collection of ‘basic principles’ (discussed in section 3.3) to help conceptualise the following key points that I have identified to be crucial to this thesis; see Table 3.

<u>Key points</u> from Activity Theory that are crucial to this thesis
<ul style="list-style-type: none">• The motives of those involved in activity• Relationships that exist amongst those involved in activity• The historical development of an activity• Implicit and explicit social practices of the context in which activity is carried out• The operational structure of an activity• Issues surrounding the development and use of tools to support activity

Table 3: Key points from Activity Theory that are crucial to this thesis

The key points outlined in Table 3 represents possible areas in which Activity Theory can be used to leverage HCI design. These key points will not be considered independently, instead, I will use them holistically as a benchmark or constant point of reference in ongoing discussions especially in case study investigations in chapters five, six and seven. It is not the intention of this thesis to explore all principles that Activity Theory encompasses as this would be outside the scope of the current work. The essence and significance of the key points listed in Table 3 to HCI design will become clear in section 3.4 once this chapter has discussed the historical development of Activity Theory and also following a detailed illustration of basic principles of Activity Theory.

3.2 Historical Development of Activity Theory

The ideas presented in Activity Theory have their origins in the Vygotskyian concept of tool mediation and Leont’ev’s notion of activity. Vygotsky (1978) originally introduced the idea that human beings’ interactions with their environment are not direct ones but are instead mediated through the use of tools and signs. Detailed discussions about Vygotsky’s theorising are presented as follows.

3.2.1 Vygotsky's Theorising

Vygotsky had set out to establish and explain the developmental patterns of the human mind as a means for understanding human behaviour. In developing his theory of higher psychological processes in human beings, he rejected prevailing approaches to understanding human mind through experimentation or reflexology. Human "mind, it was believed, could now be measured and explained according to the canons of experimental science" (Cole, 1996, p.7). Commonly referred to as the *stimulus – response* theories of behaviour, such approaches to studying human behaviour were popular with scientists of the time amongst others; Sechenov, Wundt and Pavlov (see Vygotsky, 1978, p.3). Reportedly, Sechenov's (Vygotsky, 1978) investigations on simple sensory-motor reflexes led him to propose the possibility of associating animal studies to human beings.

“Sechnov, was convinced that the processes he observed in the isolated tissue of frogs were the same in principle as those that take place in the central nervous systems of intact organisms, including humans”(Vygotsky, 1978, page 2).

Vygotsky's main criticisms of psychological theories of the time (e.g. reflexology, stimulus – response) was that they attempted to explain consciousness or the human mind by reducing it into a series of atomic components or structures that were drawn from the brain itself (stimulus – response chains). Vygotsky argued that, if one is to understand human mind (consciousness), the explanatory principle must be sought elsewhere but not in the human mind itself. Laying the foundation for his *notion of tool mediation*, he then went on to highlight the *social and cultural* aspects of human mind as reflected in human activity. Human mind, Vygotsky argued, is made explicit in cultural tools, which he interpreted as signs and words, which cause changes in that activity, and thus its internal mental reflections (Vygotsky, 1978). According to Vygotsky, human higher mental functions must be viewed as products of mediated activity through the individual's social and cultural interactions with the environment using tools. This interaction is realised through the individual's 'objective' activity.

Vygotsky further elaborated his ideas of socially and culturally mediated tools by introducing the principle of *internalisation* in which he explains that individual consciousness does not exist inside the individual's head, but exists instead outside the individual through interactions with his environment. “Vygotsky believed that the internalisation of culturally produced sign systems brings about behavioural *transformations* and forms the bridge between early and later forms of individual development,” (Vygotsky, 1978, page 7). This transformation of the individual through internalisation reflects the *dual* or double aspects of tool use. Vygotsky reiterates this idea of transformation through internalisation with reference to the functions of the tool and the sign in mediating human activity.

“The tool’s function is to serve as the conductor of human influence on the object of activity; it is externally oriented; it must lead to changes in objects. It is a means by which human external activity is aimed at mastering, and triumphing over, nature. The sign, on the other hand, changes nothing in the object, of a psychological operation. It is a means of internal activity aimed at mastering oneself; the sign is internally oriented,” (Vygotsky, 1978.page 55).

In formulating his ideas about tool mediation, Vygotsky was influenced by the Marxist philosophical approach of *dialectical materialism*¹ whereby tools or instruments mediate the labour activity.

“For Marx and Engels, labour is the basic form of human activity. It lies at the foundation of any explanation of social-cultural history and of the psychological characteristics of the individual. Their analysis stresses that in carrying out labour activity, humans do not simply transform nature: they themselves are also transformed in the process (Vygotsky in Wertsch, 1981, page 134).

Vygotsky’s explanation of his concept of tool mediation encompasses both physical and psychological tools namely: signs and symbols. The notion of tool mediation is

¹ Dialectical materialism emphasised the importance of economic factors as determinants of the history of society. The basic tenet is that everything is material, and that change and development takes place through the conflict of opposing forces. The intellectual life of society is reflected through the economic structure since human beings create the forms of life solely in response to economic needs (Vygotsky, 1930/1981).

central to Vygotsky’s theorising because tools allow humans to interact more effectively with objects. Therefore, enabling them to relate more efficiently to their external environment and to control it.

The Mediational Triangle

Vygotsky used the operational structure of the sign to represent *unmediated* or elementary forms of behaviour, as is the case with animals that normally react ‘directly’ to their environment. He expressed this representation using the following formulae: (Vygotsky 1978, page 39).



Figure 1: Shows ‘unmediated’ behaviour (as reflected in animals) (Vygotsky 1978, p.39).

To show the structure of *mediated* or ‘indirect’ form of behaviour, which is common to humans, Vygotsky introduced “an intermediate link between the stimulus and the response” represented by an X. See Figure 2.

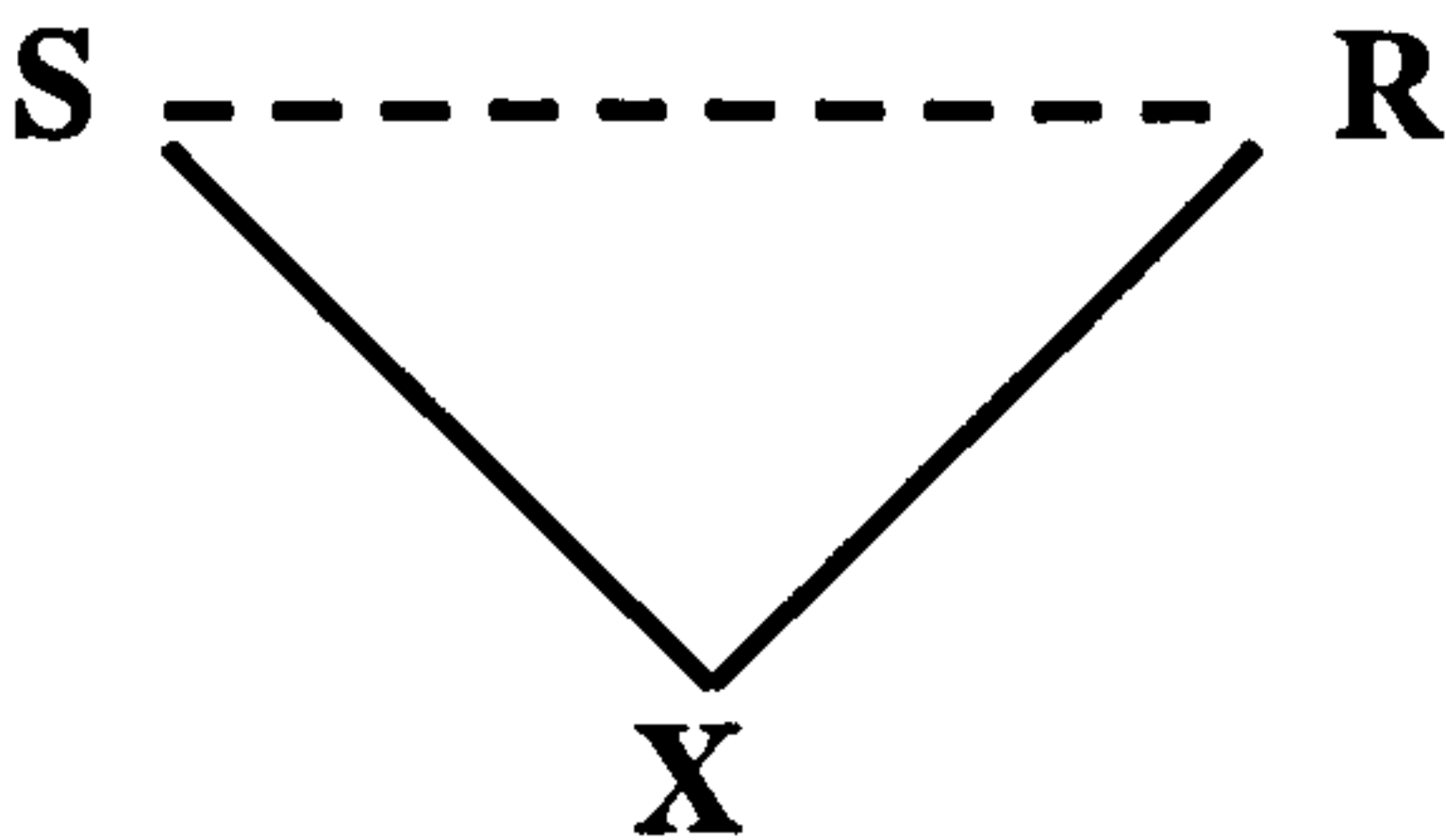


Figure 2: Shows ‘mediated’ behaviour (as evident in Humans) (Vygotsky, 1978, p.40).

The S-R-X triangle model has since come to be represented as shown in Figure 3 in current literature (see for example, Cole 1996, page 119; also Engeström, 1999, page 30.).

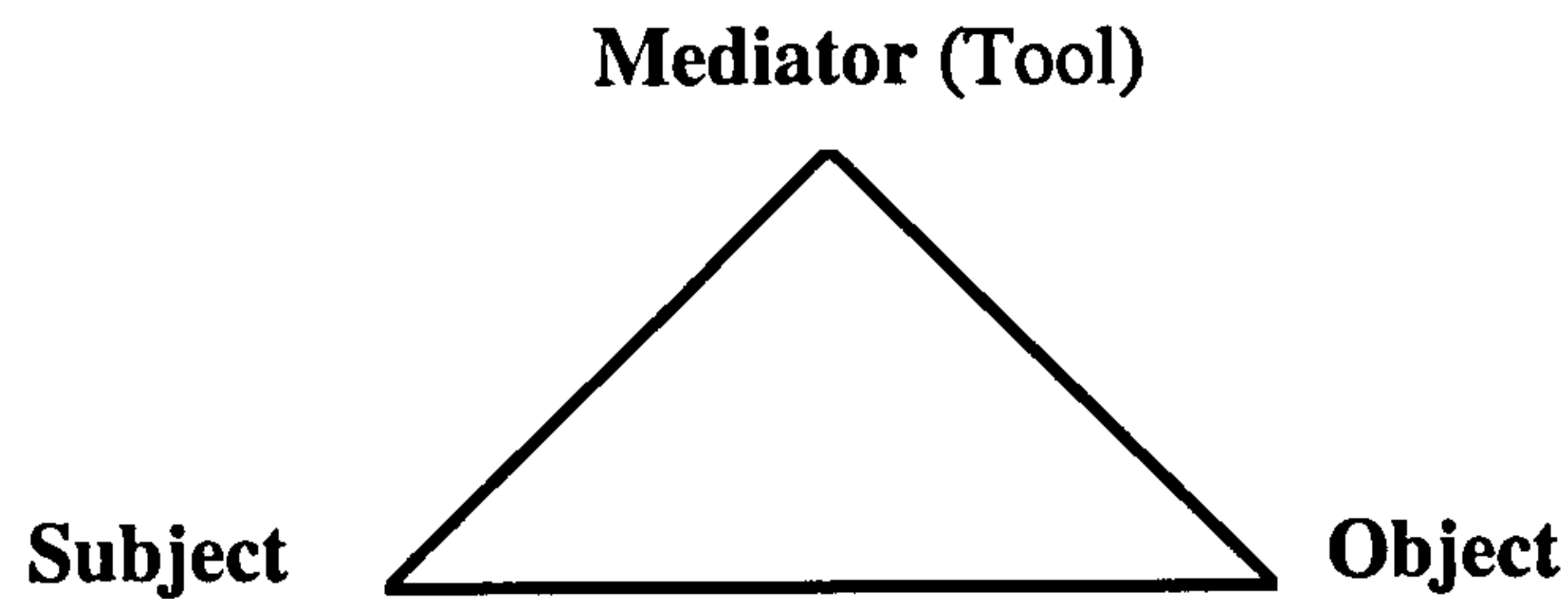


Figure 3: Mediation Model as usually represented in the current literature.

The two diagrams presented in Figure 2 and 3 are conceptually equivalent. They both depict the same notion – the mediational aspects of human activity. These two figures are shown twice so as to illustrate the differences in representation between Vygotsky’s original representation for mediated behaviour (Figure 2) and the model commonly used in current literature (Figure 3). I will use the current representation (Figure 2) in all future references to the mediational model.

Why Vygotsky?

Other psychologists, for example P.P.Blonsky, as reported in Vygotsky (1978, page 8) had already thought about the idea of linking developmental and historical approaches to the study of man’s nature by the time Vygotsky came on the scene. Blonsky adhered to the tenet that “technological activities of people were a key to understanding their psychological makeup” (Vygotsky, 1978, page 8). During the time of Vygotsky, Alexander Luria one of Vygotsky’s followers and students argued that human beings’ ways of thinking and reasoning are indeed culturally mediated and change when ways of life undergo transformations. Luria showed that the human brain is a flexible organ that works collaboratively with cultural tools and signs to enable humans to re-mediate their activities even when they are seriously impaired by injury.

Vygotsky’s main contributions to the study of man and his nature lies in the fact that he succeeded in criticising the view that higher psychological functions in human beings can be understood by simply multiplying and complicating principles derived

from animal psychology. He also rejected the idea that elementary mental processes naturally and progressively ‘mature’ into higher mental processes. Instead, he proposed an approach based on the Marxist view that historical changes in society and material life produce changes in ‘human nature’ (consciousness and behaviour). This led Vygotsky to suggest that in order to understand the human mind (higher mental functions), there is a need to understand their origins in social and cultural terms. This would involve establishing how these social and cultural functions are externalised and internalised as human beings interact with their environment. Vygotsky therefore initiated the effort to associate psychological concepts to human behavioural questions of the day.

However, as will become evident in the next paragraph, there seem to be difficulties associated with the interpretation and practical application of Vygotsky’s innovative contributions to the study of higher psychological functions in human beings (Cole, 1996; Engeström, 1987). This chapter will now illustrate these difficulties by discussing some of the problems associated with Vygotsky’s work. Thereafter, a review of how Vygotsky’s work was extended by Leont’ev (1978 and 1981) will be presented.

Interpreting and Applying Vygotsky’s ideas

Vygotsky’s main concern was to establish basic principles of his theory and method. He was less concerned about conducting empirical studies to support his ideas (Cole, 1996). Instead of pursuing any particular line of thinking more deeply, he concentrated on opening up new lines of investigations. The generality of the summaries from his experiments makes it difficult to interpret and practically apply his concepts, because there are no statistical tests or raw data on which to base records and observations. As a result of this, Vygotsky’s ideas have been interpreted and applied differently by various scientists. The lack of empirical testing of his theories could be attributed to the fact that Vygotsky’s concept of the experiment differed from that of the Anglo-American psychology, therefore, understanding of this difference is important for an appreciation of Vygotsky’s contribution to

contemporary psychology, (see Vygotsky, 1978.p.11; Cole, 1996, pp.38-68).

Furthermore, Vygotsky's principle of the social origins of human mind seems to take a narrow view of the individual's behaviour within a much broader context of society. These views are expressed in writings of several authors including, Engeström and Miettinen (1999, pp.1-16), Engeström (1987 and 1999, pp.19-38). For example, Engeström and Miettinen (1999) make the following comments about the mediational model (Figure 2):

“Mediation by other human beings and social relations was not theoretically integrated into the triangular model of action,” (Engeström and Miettinen, 1999, page 4).

It is therefore, difficult to recognise the roles played by other human beings within the social and cultural matrix from which the individual's behaviour emerges when using the original mediational model (Figure 2 and 3). Collaborative aspects of the individual's behaviour are reflected in interactions and relations with others within society, and they influence how an individual behaves in a particular context. Given this stance, the unit of analysis in Vygotsky's model is therefore, the object-oriented individual interacting with the environment using mediating signs or words.

The significance of this observation will now be explored by examining the work of A.N. Leont'ev (1981), one of Vygotsky's students.

3.2.2 The Concept of Activity – Leont'ev

In recognition of the importance of the collective aspect of human activity, A.N. Leont'ev (1978), expanded Vygotsky's work by conceptualising the '*theory of activity*'.

“This first description now, after a quarter century, appears in many ways unsatisfactory and too abstract. But it is exactly owing to its abstractness that it can be taken as an initial departure point for further investigations. Up to this point we were talking about activity in the general collective meaning of that concept. Actually, however, we always must deal with specific activities...” (Leont'ev, 1978).

Leont’ev (1981, page 208) distinguished between ‘collective activity’ and ‘individual action’. This distinction is evident in Leont’ev’s reconstruction of the essence of the ‘division of labour’ as a vital historical process behind the development of mental functions (1981, page 208). He developed the notion of the *hierarchical levels of activity*. In his model of human activity, he isolates the individual’s activity from the collective activity system of society and introduces a structured representation of human activity. According to Leont’ev (1978, 1981), activity is a complete system that has a structure.

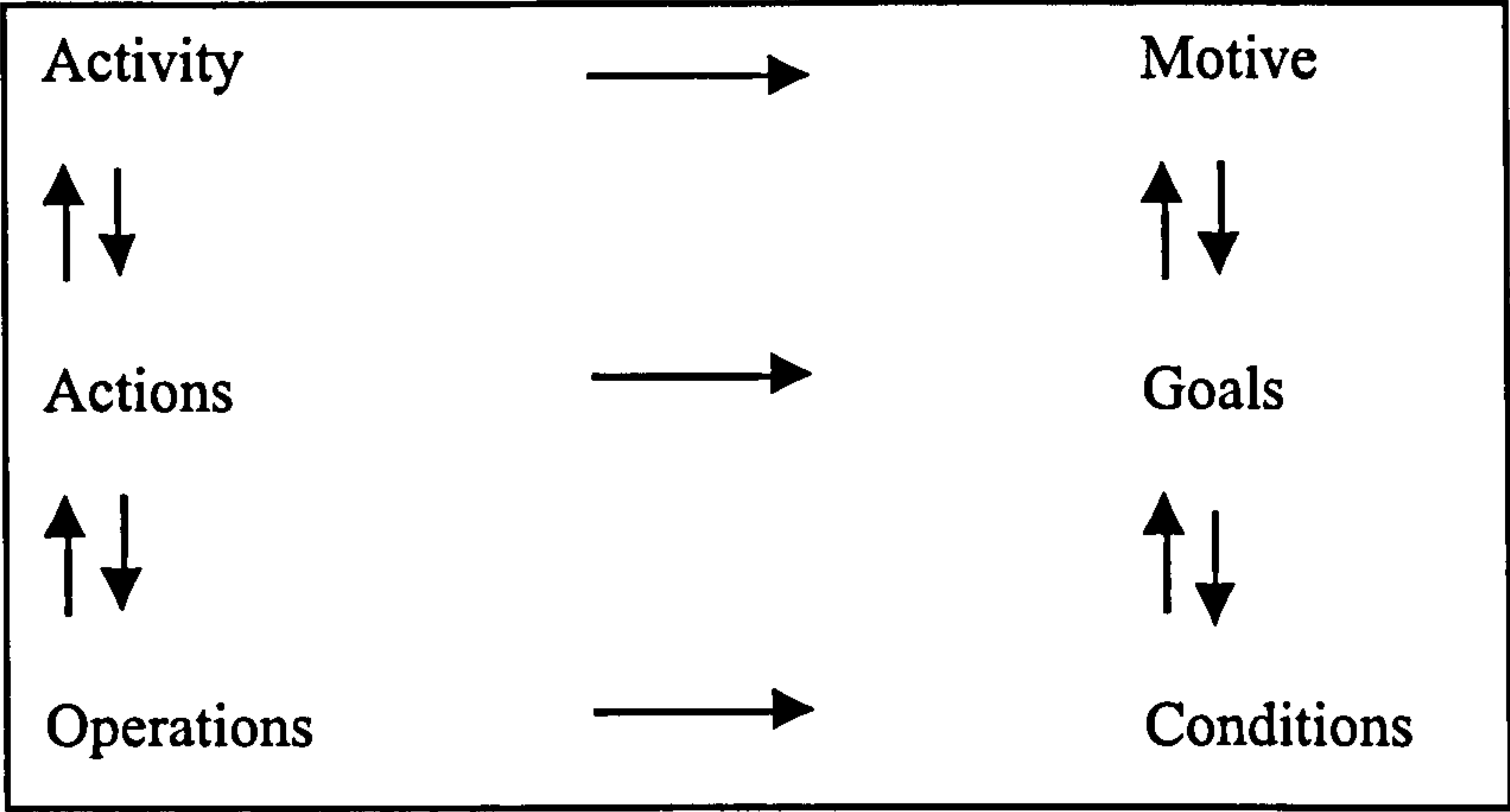


Figure 4: Hierarchical Model of Activity (Leont’ev, 1978)

The structure of an activity can be understood from the viewpoint of a selected single (specific) activity portrayed at three different hierarchical levels. The three levels of activity consist of an *activity* that has a *motive (objective)* or a need; *actions* that are directed towards the achievement of desired *goals*; and *operations* that are controlled by the *conditions* of execution.

Leont’ev explains his ideas by arguing that human activity does not exist except in the form of actions or a chain of actions. Actions represent conscious goal-directed processes² that must be undertaken to fulfil the objective of an activity. The

² The word *process* is used here to refer to a series of steps or procedure for executing a particular action, as used in Preece et al’s definition of ‘procedural knowledge’ (Preece et al, 1994, p.164).

objective of an activity stimulates the activity but does not direct the orientation of the subsequent activities that may exist within that activity. Motive therefore, represents the necessary precondition for an activity to occur. In other words an activity exists to satisfy a motive or a human being's objective need to engage in activity. Therefore, the objective of an activity can be identified through the motive. A motive could be explicit or inexplicit (material or ideal), it can be perceived or imagined. This explanation highlights the view that there is no such thing as a motiveless activity. Therefore, "an activity does not exist without a motive; 'non motivated' activity is not activity without a motive but activity with a subjectively and objectively hidden motive," (Leont'ev, 1978). An activity is therefore driven towards the satisfaction of the motive or need.

In the same way that an activity is focused on satisfying a motive, *actions* are targeted towards the achievement of identified *goals*. A single action or several actions may be directly or indirectly targeted towards the achievement of a single or several goals. Actions could therefore, be understood as goal-directed processes. The goal of an action is a conscious mental representation of the desired outcome from the activity system. Actions have a temporary life span (existence) in relation to an activity. They tend to be relevant to a particular activity or activities only at particular times. Sometimes, actions are performed repeatedly until a desired goal is achieved. These repeated or routine actions are transformed into operations once humans master or internalise the procedures for executing them. To illustrate this idea, Leont'ev uses an example of a person learning to drive a car. In this example, the activity of driving a car involves the manual actions of changing gears to increase and reduce speed. Initially the individual has to consciously think about how to shift these gears. This involves making decisions as to which gears to shift into in relation to what speed of acceleration. Once these actions or processes have been mastered by the learner, they get *internalised* and transformed into operations that are *externalised* or executed automatically by the learner. This internalisation and externalisation process can lead to changes that may result in the emergence of new developments in the activity of driving a car. New developments could emerge in

the form of changes in the way the learner perceives the activity of driving a car. Leont'ev explains that this transformation process brings about new understanding of the activity that a human being is involved. "In man the formation of functional systems that are specific to him takes place as a result of his mastering of tools (means) and operations."

Leont'ev (1978) further explains that actions are satisfied through *operations*. The operational aspects of actions become routines and unconscious with practice. This means that the psychological function of having to think about how to perform a particular action or actions diminishes with repetitive practice enabling actions to develop into operations (becomes natural, don't have to think about it). The successful execution of operations is dependent on the *conditions* under which a particular action is performed, one of the conditions being that the goal and objective of that activity remains the same. This implies that operations are controlled by the conditions in which the goal is presented. As a result of the influence from conditions of execution, an operation can become transformed into a series of actions once changes in the normal conditions of execution occur. To borrow Leont'ev's example of the activity of driving a car, if a gear lever attached to gearbox continues to function as intended then the operational actions of changing gears can be executed smoothly by an experienced driver. However, in a situation whereby a gear lever comes off or gets stuck in a particular gear, then even an experienced driver's operation of changing gears becomes transformed into actions because they now need to consciously (improvise) use psychological processes to execute actions of changing gears. Even though the operational structure (ways of doing it) of changing gears is transformed into actions, this transformation does not affect the goal of changing gears. The goal remains the same. In terms of human activity in an organisation, changes in conditions of operation could include the changes in the type of resources available for reaching goals, for example, the introduction of new rules and regulations for carrying out certain actions.

According to this framework, different parts of an activity can be transformed dynamically as a result of changes occurring in the conditions in which that particular action is being carried out. The levels of activity can move both up and down from action to operation level, then again when conditions prevent the successful execution of operations, move back to action level. Whilst goals, actions, and operations can change as a result of a problem preventing the successful execution of actions, the objective or motive for carrying out that activity does not change. By recognising that changing conditions can reshape the structure of an activity, Activity Theory offers flexibility in the perception of human activity. In so doing, Activity Theory highlights an important distinction that does not exist in task analysis methods used in HCI for example the GOMS model (Card et al., 1983). *Leont'ev insists that his idea of hierarchical levels of activity does not break up the activity into elementary constitutive components but instead outlines the relationships that exist between the various actions and operations contained in an activity.* According to Leont'ev (1978) isolating the 'units' of an activity is important because it helps to identify the various internal and external processes that form an activity. He also emphasises the view that by establishing these processes together with their relations, it is possible to reveal the internal and external transitions that transform the activity system. These transformations or changes in the activity lead to new developments within the activity system.

Comments on Leont'ev's expansion of Vygotsky's work

Leont'ev's hierarchical model of human activity has been strongly criticised for putting emphasis on 'what is being done' – activity; therefore, paying little attention to those engaged in carrying out activity – the human subjects (see for example, Davydov (1999, p.39-52; Lektorsky, 1999, p.65-69).

“Leont’ev wrote about the significance of mediation in human activity. Nevertheless, in his theory the greatest attention was given to the relations between activity, actions, and operations; in other words, to the subjective but not the intersubjective side of activity. The intersubjective relations that arise in the context of artificial objects have not really been investigated in his works” (Lektorsky in Engeström et al., 1999, page 66).

Even though Leont’ev’s model helps to conceptualise the inter-relatedness of various actions in an activity, and also how these are linked to the goals and shared objective of that activity, it does not say much about the roles and responsibilities of individuals involved in carrying out activity. Whilst both the ‘subjects’ and ‘division of labour’ are hypothetically addressed in Leont’ev’s theory of activity, these components of human activity are not represented in his hierarchical model of human activity. The significance of this observation will become clear in chapter five (section 5.3.2) when the thesis considers how to interpret the activity triangle model (Figure 5 in section 3.2.3) in an attempt to operationalise it for systems design purposes. In the meanwhile, this part marks the end of the literature review on the historical developments of Activity Theory. The next section discusses more recent developments of both the works of Vygotsky and Leont’ev by reviewing Engeström’s (1987) approach to Activity Theory.

3.2.3 The Activity System - Engeström

Inspired by Vygotsky’s (1978) concept of tool mediation, and also Leont’ev’s (1978, 1981) notion of activity, Engeström (1987) expanded Vygotsky’s original representation for mediated human behaviour - ‘mediational model’ (Figure 3). He developed an expanded version of the mediational model of human activity - the *Activity System* (Figure 5 in the current section). In so doing, *Engeström’s (1987) approach extended Vygotsky’s representation of mediated behaviour by producing a model that reflects both the collaborative and collective nature of human activity. In addition, Engeström’s approach also expanded Leont’ev’s work by incorporating the ‘subject’ component, to represent those engaged in carrying out activity, also the*

‘division-of-labour’ component, to represent and make the various responsibilities of those engaged in activity explicit.

Detailed explanations of the various components of the ‘Activity System’ are presented as follows.

The ‘Activity System’ also referred to as the ‘Activity Triangle Model’ incorporates the following components: *Subjects*, *Object*, *Community*, with mediators of human activity, namely, *Tools*, *Rules* and the *Division of Labour* into a unified whole.

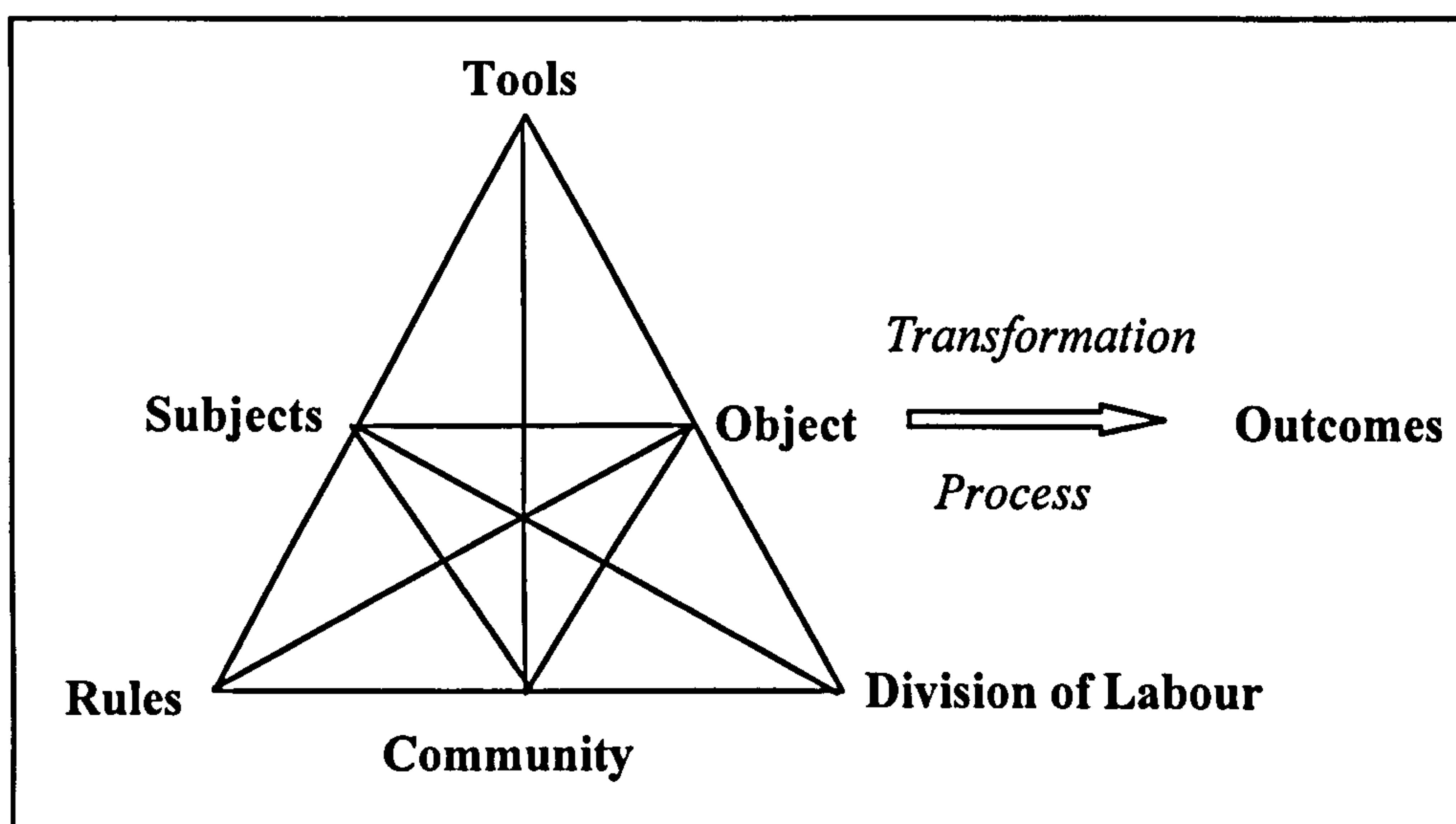


Figure 5: The Activity Triangle Model or Activity System (Engeström, 1987)

Components of the activity system are discussed in detail as follows:

The ‘*Object*’ component portrays the purposeful nature of human activity, which allows individuals to control their own motives and behaviour when carrying out activity.

The ‘*Subjects*’ component of the model portrays both the individual and collective nature of human activity through the use of tools in a social context so as to satisfy

desired objectives. The subjects' relationship with the object or objective of activity is mediated through the use of tools.

The '*Tools*' component of the model reflects the mediational aspects of human activity through the use of both physical and psychological tools. Physical tools are used to handle or manipulate objects, they therefore extend human beings' abilities to achieve targeted goals and satisfy *objectives*. Psychological tools are used to influence behaviour in one way or another.

The '*Community*' component represents stakeholders in a particular activity or those who share the same overall objective of an activity. The community component puts the analysis of the activity being investigated into the social and cultural context of the environment in which the subject operates.

The *Rules* component highlights the fact that within a community of actors, there are bound to be rules and regulations that affect in one way or another the means by which activity is carried out. These rules may either be explicit, or implicit, for example, cultural norms that are in place within a particular community. The rule component of the activity triangle model also helps to establish environmental influences and conditions in which activity is carried out.

The *Division of Labour* component reflects the allocation of responsibilities and variations in job roles and responsibilities amongst subjects involved in carrying out a particular activity within a community.

The *Activity System* consists of several sub-activities that are interconnected and united through the shared objective on which activity is focused. As a result of this inter-connectedness, disturbances or contradictions can occur *within* and *between* sub-activities that could affect the transition of the collective activity system. The term '*contradictions*' is used in Activity Theory to refer to misfits, disturbances, problems or breakdowns that occur in an activity system or human practices being

examined (Kuutti, 1996, p.34; Bødker, 1996, p.150). According to Engeström (1993 and 1999), contradictions reflect a source of development or represent the presence of unfamiliar elements whose study is necessary so as to establish the kind of new developments that are taking place within an activity system. In order to understand the kind of developments taking place in an activity system, there is a need to analyse the relationships that exist within and between the sub-activities. This analysis ought to be focused on establishing the means by which mediation tools support, access and interpenetrate the various levels of these sub-activities and their connectivity. This kind of approach can help to reveal the productive and communicative aspects of human activity at all levels of operations. Communicative aspects of human activity are reflected in day-to-day human interactions during activity. The significance of communication to human activity is evident in the vital role that collaboration occupies in human activity. Davydov (in Engeström et al., 1999, pp.46-47) in his discussions of some of the ‘unsolved problems in activity theory’ stresses the fact that communication and human activity are two inseparable notions of equal importance. He argues that communication is the process by which social and cultural relations of a particular activity are revealed.

“Communication can exist only in the process of different kinds of activity realization by people. At the same time, one cannot study communication and evaluate its role in people’s lives without examining their activity” (page 47).

Communication therefore facilitates ‘sense-making’ when analysing actions and relations of sub-activities in an activity system. Given this stance, sense-making actions can be understood in terms of the effectiveness of the actions support processes that are in place. Comprehending these processes involves the analysis of the various communicative interactions that exist between subjects or participants of a particular activity so as to capture conversations and comments made during activity. The facilitation of co-ordination or the negotiating of the motivational aspect of these conversations can also form a very important means of establishing sense-making in communications of an activity. The Activity System (Figure 5) will be reconsidered in much detail in the next chapter when the thesis considers the

practical aspects of using Activity Theory to inform HCI design. In the meanwhile, the section that follows hereafter discusses 'basic principles of Activity Theory'.

3.3 Basic Principles of Activity Theory

Foregoing discussions have so far concentrated on evaluating the historical context for the development and interpretations of Activity Theory ideas. However, in order to be able to confidently use Activity Theory to inform HCI design, it is important to understand not only the historical aspects, but also more importantly its fundamental tenets so as to fully comprehend the practicalities of using this framework. Therefore, this section discusses some of the 'basic principles of Activity Theory' as explicated by Kaptelinin (1996.pp.107-110), and Cole (1996.pp.108-111). These are outlined as follows:

- The concept of object-orientation
- The concept of tool mediation
- The concept of internalisation and externalisation processes
- The concept of historical development
- The concept of consciousness
- The concept of context

The necessity of discussing these basic principles of Activity Theory emerge from the identified need to fully comprehend the various design perspectives addressed by each principle and also to establish the extent to which their interpretation can influence current understanding and application of Activity Theory within HCI research and practice. Before we proceed into detailed discussions of these basic principles of Activity Theory, it is worth pointing out that the presentation order employed to illustrate these concepts in this thesis does not suggest supremacy of one concept against the other. This is so because Activity Theory concepts are highly intertwined with each other and it is difficult to isolate one principle from the other without mis-interpreting the notions. Consequently, there are overlaps in discussions of these concepts. The approach taken to presenting these concepts

makes it possible to structure and ensure clarity when explaining basic principles of Activity Theory to the target audience of this thesis – the HCI community, many of who are not specialists in Soviet developmental psychology. At this point, it is also emphasised that the basic principles outlined above are not intended to give a comprehensive representation of all theoretical concepts of Activity Theory. Instead I have selected those concepts that are widely discussed in the literature. See for example, Kaptelinin (1996) and Cole (1996), both of whom give a more comprehensive coverage of basic principles of Activity Theory. Finally, the other deciding factor for selecting to discuss the outlined basic principles draws from the fact that they seem to be relevant to both the analysis of work practices and system design, both of which are key concerns of HCI design. Detailed discussions about the basic principles of Activity Theory are presented as follows.

3.3.1 The concept of object-orientedness

According to Activity Theory, human activity is to be understood as continuously developing *object-oriented* individual and collective processes or actions that transform the object of activity into a desired outcome. This notion is not to be confused with the ‘object-oriented’ concept used in the computing science and programming fields of study. In Activity Theory, the principle of object-orientedness refers to the need to focus on the ‘object’ of activity when trying to understand human practices, since “transforming the ‘object’ into an outcome motivates the existence of an activity” (Kuutti, 1996).

An ‘object’ according to Kuutti (1996.p.27), “can be a material thing, but it can also be less tangible (such as a plan) or totally intangible (such as a common idea) as long as it can be shared for manipulation and transformation by the participants of the activity”.

The idea that a motive drives the existence of an activity implies that human beings consciously or unconsciously engage in pre-determined or purposeful activity. The motive of human activity is reflected through the ‘object’ or ‘objective’ of that activity. For this reason the term ‘object’ in this thesis is used in the sense of the ‘objective’ so as to reflect and emphasise the purposeful nature of human activity.

Others have also used the term ‘objective’ in this way. For example, Nardi (1996, p.73) gives the following definition, “an *object* (in the sense of “objective”) is held by the subject and motivates activity, giving it specific direction.” See also, Leont’ev (in Wertsch, 1981.pp.46-53) in his discussions of ‘the category of objective activity’.

“In connection with the analysis of the activity, it is sufficient to point out that its *objective* produces not only the objective character of images but also *object-orientation* of desires and emotions” (page 50).

Activity Theory’s notion of object-orientation therefore implies that human beings always have a motive for engaging in activity. A motive might be conscious or unconscious. According to this idea, human beings participate in activity so as to consciously or unconsciously satisfy an already established motive or need. A motive therefore, pre-determines the structure of an activity by driving the existence of an activity (Leont’ev, 1978). The idea of motive reveals the purposeful nature of human activity, which allows human beings to control their own behaviour from inside (internally) before they can externalise it. Human beings are therefore able to control their own behaviour by targeting their actions towards the achievement of certain goals. At the same time humans are able to suppress certain actions to prevent them from maturing into undesired outcomes. Whilst participating in an activity, individuals tend to have various and differing motives for getting involved in activity. Variations in motives do not necessarily affect the overall objective of activity, which transforms into an outcome.

3.3.2 The concept of tool mediation

The key notion of tool mediation is extremely important and at the core of the theorising in Activity Theory. It presents the view that human beings develop and use tools to help them achieve targeted objectives. They do this by using tools to ‘mediate’ their interactions with objects of the environment during activity. The term *mediation* refers to the introduction of a third intermediate party in between two

entities (see illustration in Figure 3. section 3.2.1). This mediator acts as the means for establishing the link and history of the relationship between the two entities (See also Kuutti, 1996.pp.26-27). Tools therefore, have a mediating role in human activity. The idea of tool mediation helps to establish the relationship between human beings and their objectives for engaging in a particular activity. The notion of ‘tools’ as mediators of human activity has been used in the literature to refer to both physical and psychological tools (see for example, Vygotsky³, 1978; also, Cole, 1996). A tool could therefore be something physical, for example, a hammer or a computer keyboard; it could also be something psychological as in a sign. Physical tools are used to handle and manipulate things in the environment, whilst psychological tools are used to influence behaviour in one way or another.

According to this framework, tools are social entities. They are developed and redeveloped as a result of social and cultural transformations that occur in the environment in which activity is carried out.

“Tool mediation is a way of transmitting cultural knowledge. Tools and culturally developed ways of using tools shape the external activity of individuals and through the process of internalisation influence the nature of mental processes (internal activity),” (Kaptelinin, 1996, page 53).

Activity Theory is focused on establishing the means by which human beings master and use tools in everyday activity from a social, cultural and psychological perspective. This stance is based on the premise that the tools that individuals use to carry out activities as they strive to satisfy desired objectives not only facilitate the performance of activities at hand; they also reveal and transform the individual’s mind. For example, through the development and use of psychological tools, human beings internally transform their own and other people’s perceptions of the activity

³ Vygotsky (1978.pp.19-30) in his discussions of the ‘tools and symbol in child development’ clearly distinguished between two kinds of mediation; one which involves the use of psychological tools e.g. signs and symbols as used in speech; and the other, which involves the use of instruments or physical tools as in a hammer. See also page 51 - example of a human being’s use of a tied knot in a handkerchief (physical) as an aide mémoire. Cole (1996.p.117) also presents a similar line of thinking by reiterating Vygotsky’s view that all tools have both material and ideal aspects.

that they are engaged in. At the same time, by developing and using physical tools, human beings externally transform the activity that they are engaged in. *The significance of the notion of tool mediation arises not from the fact that humans develop and use tools to help them achieve desired objectives; but it is due to the fact that, through the development and use of tools, human beings change not only the activity that they are engaged in, but also more importantly, they transform their internal mental perceptions about the activity that they are engaged in.*

“Mediation by tools and signs is not merely a psychological idea. It is an idea that breaks down the Cartesian walls that isolates the individual mind from the culture and the society. ... This perspective is not only optimistic concerning human self-determination, it is an invitation to serious study of artefacts as integral and inseparable components of human functioning” (Engeström, 1999, page 29).

This line of thinking implies that we need to understand the means by which human beings develop and naturally incorporate tools within their social and cultural matrix. The implications of this statement are that the way a tool is designed can determine whether or not that tool is introduced in activity, how it is introduced and why (Bellamy in Nardi, 1996, p.124). For it is through the design of a tool that a system’s developer determines, creates and changes the operations and conditions of an activity because the use situation becomes the object of designing the tool. “In designing an artefact or a tool, we also design new conditions of use for collective activity e.g. new division of labour, means for co-ordination, control and communication” (Bannon, 1990). The concept of tool mediation can therefore help to address issues relating to the enabling and limiting aspect of the tool through its design. The way a tool is designed can determine how it is used, and it can also extend and limit human beings’ abilities to achieve desired goals and objectives.

The enabling and limiting aspects of the tool in relation to human activity are well illustrated in the *notion of functional organ*. According to Kaptelinin (1996, page 50), “functional organs are functionally integrated, goal-oriented configurations of the internal and external resources” used in human activity. This concept suggests

that there is no functional boundary between the human mind (which is internal) and the tool (which may be external) during activity. Instead, they both collaborate and merge into a single functional organ when carrying out activity together in order to achieve an objective that results into a desired outcome (Kaptelinin, 1996, pp.45-68). Therefore tool mediation in the sense of the ‘notion of functional organ’ enables the human and the tool-in-use to become linked through the object of activity.

3.3.3 The concept of Historical Development

The Activity Theory notion of the historical development of human activity presents the view that activity develops and re-develops as a result of social and cultural changes that occur in the community where it is performed. These changes thereby transform activity. As a result of this transformation, human activity accumulates a history of its development. “In addition to making tools, human beings arrange for the rediscovery of already-created tools in succeeding generations” (Cole, 1996.p.109). Given this awareness regarding the development of human activity, it is necessary to understand the evolutionary aspects of human activity from a social and cultural point of view. This understanding could be accomplished by analysing the historical development of activity so as to establish the reasons why activity is carried out in a particular way. This could offer insight into the reasons for introducing the kind of tools being used in that activity. Understanding the historical development and use of tools that mediate activity demands the need to study activity in a particular context so as to understand how people use already existing tools within that cultural setting.

3.3.4 The concept of internalisation and externalisation

Key to this principle is the idea that human mental processes develop and redevelop as a result of external activity during which time humans internalise cultural knowledge about an activity. These processes are social and cultural in nature, and develop over a period of time. Therefore human beings acquire new abilities as a result of human-to-human interactions when carrying out activity. The existence of the ‘external’ and the ‘internal’ implies that a transformation process occurs in the

human mental perceptions of the activity. This internal and external perception of human activity portrays the dual aspects of human activity. The dual nature of human activity suggests that human beings assimilate social and cultural knowledge about the activity being carried out. This occurs through the *internalisation* process. In HCI, this internalisation process is the means by which computer tool users form metaphors or internal mental representations of both the activity that they are engaged in, and also the usage patterns for the computer tool employed to mediate that activity. Therefore, the kind of knowledge absorbed during the internalisation process could reveal the historical methods of carrying out that activity. In addition, it could also unveil vital information as to why that activity takes place, including the development and use of tools to mediate that activity. Once this information is sorted and absorbed 'inside' the individual's head, human beings then externalise (put outside the head) this knowledge by actually carrying out that activity for real using physical tools (e.g. a hammer). This way, human beings transform their internal mental representation (inside their heads) of activity and externalise it (outside their head) as evident in mediated activity.

“A person's internal activity assimilates the experience of humanity in the form in which it manifests itself in the corresponding external activity... It means that a person's mental processes acquire a structure necessarily linked to socio-historically formed means and modes, which are transmitted to him by other people through teamwork and social intercourse” (Kuutti in Nardi, 1996, page 33, quoting from Leont'ev, 1974).

The two sides of human activity do not exist in isolation. There are no boundaries between the internalisation and externalisation processes. The two processes co-exist into a single functional organ. “Human activities include external and internal components at every stage” (Kaptelinin in Nardi, 1996, page 51). Cole (1996, pp.137-139) reiterates this idea in his discussion of the relationship between the 'ideal' (internal) and the 'material' (external) aspects of human activity. He contends that activity is not just something external or different from the person conducting it, it is his mind in an objectified form. Cole further explains that the

dual nature of human activity gives activity unique properties that allow it to exist both internal ('inside' the head) and external ('outside' the head) to the producer.

However, accepting Activity Theory's idea that human activity can exist both inside and outside individuals' heads, presents computer systems designers with challenges. These could relate to how to represent the individual's conceptualised world into a 'real' world that can be shared collectively with others involved in that activity. Effective representation of the conceptual world into a real world would require the development and use of appropriate tools both physical and psychological (e.g. computer tools, mental models, language) to help users to collectively create and share the conceptual world. This kind of tool facilitates the elicitation of individuals' mental models of the activity being carried out, also the purpose for carrying out that activity. Thereafter, they support the co-construction of a collective representation of that activity whilst at the same time being able to deal with contradictions that may exist. To accomplish this, tool developers need to establish potential users' internalised knowledge about the activity and the kind of tools used to mediate activity, and finally, to establish what happens to that knowledge when a person moves from one activity to another.

Whilst the internalisation process relies on the use of psychological tools such as language, to absorb contextual information about a particular activity, the externalisation process employs both physical and psychological tools. For example, a product specialist in an organisation could externalise his already internalised knowledge about a particular activity by introducing new regulations (psychological tool) so as to influence a change in the way other employees carry out that activity. This internalisation and externalisation of human activity implies that humans either consciously or unconsciously pre-plan before engaging in activity. They work out inside their heads what it is they are going to do, why they are going to do it, and how they are going to do it, before they even start working on activity. To do this, human beings use psychological tools, for example language, to discuss issues relating to that activity, or to generate a plan to help them interpret rules and

regulations that guide the performance of that activity. Psychological tools therefore shape the way human beings understand and interpret the activity that they are involved in.

3.3.5 The concept of Consciousness

This principle illustrates the unity of consciousness and activity. Consciousness is an extremely elusive and difficult term to define. The use of the notion of consciousness in Activity Theory is associated with the emotional aspects and awareness of human intentions when studying activity. Emotional awareness of human intentions allows human beings to control their own behaviour by targeting their actions towards the achievement of desired goals and outcomes; at the same time, humans are able to suppress their actions to prevent the achievement of certain undesired outcomes. The notion of consciousness therefore reflects the principle unit of human mind and activity. The principle unit of human mind and activity implies that human mind can only be understood within the context of meaningful goal-oriented and socially determined actions. Activity Theory is therefore concerned with understanding the unity of consciousness and activity, for it is in activity or “everyday practice” that consciousness can be found (Nardi, 1996).

“Consciousness is located in everyday practice: you are what you do. And what you do is firmly and inextricably embedded in the social matrix of which every person is an organic part. The social matrix is composed of people and artefacts” (Nardi, 1996, page 7).

Given this perspective, the design process needs to support the development of methods and tools that help to reveal the formation of individuals’ intentions from a social and cultural perspective. Unlike some cognitive analysis of systems, Activity Theory does not assume that parallels can be drawn between human and non-human elements of systems (Vygotsky, 1978; Nardi, 1996). Humans are conscious beings, whilst computers are not. Unlike computers that can be programmed with information, it is difficult to predict human behaviour or determine how a human being is going to treat knowledge. The Activity Theory approach to addressing matters of consciousness during design could help in establishing the kind of motives

that individuals associate with particular activities. In Activity Theory an understanding of consciousness can be attained by studying the means by which the culture and history of a particular activity develops and functions in its natural environment. This entails understanding the links and connections of the individuals and artefacts in everyday activity so as to obtain a richer depiction of the tool user's situation for design and evaluation purposes. The significance of studying consciousness in HCI is reflected in the focus on the use of concepts in which consciousness is central such as the assessment of attention in direct manipulation. However, these efforts fail to account for the social and cultural aspects of individuals involved in activity. Activity Theory incorporates consciousness into a broader context of the activity system in which dynamic changes and conflicts are described and directly related to the material and social context.

3.3.6 The concept of Context

The notion of context in Activity Theory reflects the situatedness or contextual aspect of human activity. This feature of Activity Theory argues that human activity is better understood when analysed in the context of the community in which it is performed. Activity is usually carried out not in isolation but in collaboration with others within the community. Even in situations whereby an individual performs certain activities alone, they tend to carry out these in a context or a situation where there are rules and conditions that determine the way activity is performed. In this sense, many issues affect the way activity is carried out that in turn could affect the outcome of that activity. Analysing the context of activity allows the investigator to uncover issues relating to the:

- Individuals' motives in carrying out activity
- Interactions and collaborations that exist within that activity
- Rules and conditions that exist within that community or environment

The notion of context recognises the importance of analysing individuals, activity, and mediating tools within the social grouping or environment in which activity is

carried out. By studying human activity in context, it is possible to understand the relationships that exist between the individual and the tool, and also influences from the social groupings to which the individual belongs.

This part marks the end of discussions about basic principles of Activity Theory. The next section will outline key areas in which Activity Theory can help to leverage HCI design.

3.4 Contributions of Activity Theory to HCI design

The following key points initially outlined in section 3.1 (see Table 3) were identified and extracted from discussions about basic principles of Activity Theory. I shall now revisit and discuss these because they are the key points that will form the basis of the framework that underpins the Activity Theory informed design method (the AODM) that will be developed later in this thesis. The key points extracted from Activity Theory can be used to inform and enhance HCI design by helping the systems designer to understand:

- *Motives (object-ive) of those (subjects) involved in activity.* Activity Theory's support for this design aspect is reflected in the concept of object-orientedness (see section 3.3.1), which requires the researcher to focus on establishing the shared objective or motives of the subjects involved in activity. The notion of subjects includes all individuals and other stakeholders directly and indirectly involved in an activity. For examples workers directly involved in carrying out duties in an activity, and also managers who may not be directly involved in carrying out activity but regulate how workers perform their duties in that activity.
- *Relationships e.g. collaborations and contradictions (defined in section 3.2.3, under 'Activity System') that exist amongst those (subjects) involved in activity.* This feature of Activity Theory prompts the systems designer to investigate the various kinds of relationships that exist within and between subjects involved in

an activity. This includes other stakeholders in the environment in which activity is carried out. Such kind of relationships manifests themselves in the form of collaborations amongst stakeholders and also as contradictions or problems that may occur in an activity.

- *The historical development (background) of the activity.* From an HCI design viewpoint, this notion of Activity Theory requires the designer to investigate the background of the methods of carrying out the activity being studied. According to Activity Theory, such investigations should be conducted in the environment or context in which activity is normally carried out.
- *Implicit and explicit social practices (rules and cultural norms) of the context (community) in which activity is carried out:* This feature of Activity Theory requires the systems designer to take into consideration the various kinds of rules and cultural practices of the environment or community in which activity occurs.
- *The operational structure (division of labour) of the activity.* Activity Theory recognises the fact that human activity can be complex, therefore there are bound to be several contributors or participants in a given activity operating at different levels. Therefore, Activity Theory supports the idea of decomposing a complex activity during analysis so as to obtain a detailed understanding of the nature of responsibilities of those involved in activity. Also to establish the kinds of components and processes incorporated within an activity. A key point to note here is that Activity Theory does not perceive components of an activity as representative units of the main activity. Instead, Activity Theory requires the researcher to understand these components and processes from the point of view of the shared objective of the main activity system being examined.
- *Issues surrounding the development and use of tools to support activity.* This aspect of Activity Theory is mainly reflected in the concept of tool mediation (section 3.3.2). It requires the systems designer to try and understand the kind of

tools (both psychological and physical) normally used in the activity being analysed. The main aim should be to draw insights as to how and why those tools came to be introduced and used in that activity.

In order to address the issues listed above during HCI design, Activity Theory requires that the investigator get involved in a real-life situation for a duration of time so as to interact with and learn from individuals who normally perform the activity being investigated in context or the environment in which it normally occurs. Therefore, the key points illustrated above will serve as points of reference when analysing work practices in the case studies presented in chapters five, six and seven, whilst at the same time, providing an underlying framework for the Method to be developed within these chapters.

Having considered the areas in which Activity Theory can contribute to HCI design, this chapter will now revisit the HCI challenges identified in chapter two (see section 2.3) so as to produce an Activity Theory based response to the design issues raised.

3.5 HCI key design issues revisited

The challenges and design issues presented in this section were identified in chapter two following a review of HCI design methods. Whilst an HCI response to these design issues was give in section 2.3, this chapter addresses the raised design issues from an Activity Theory perspective. The presentation structure is such that, a recapitulation of the ‘challenge’ being addressed is initially given, thereafter, ‘design issues’ raised are outlined showing relevant questions that emerge. This is followed by a detailed response to the outlined questions giving an Activity Theory perspective to the design issues raised. These discussions are presented as follows:

Challenge: Need to account for evolutionary aspects of user needs and tasks

Design issues raised:

- How to conceptualise the developments and changes that occur in user tasks and requirements?
- How to differentiate between basic and advanced interactions when analysing user tasks?
- How to conceptualise relational differences and similarities that exist *within* and *between* user interactions at various levels of operation?

Activity Theory Perspective:

In order to conceptualise the evolutionary aspects of user tasks and requirements, Activity Theory emphasises the need to analyse the developmental history of the activity being investigated (Engeström, 1987). This implies studying human practices in their natural environment for a prolonged period of time. The main aim of the investigation should be to historically understand activity, not to predict its future aspects.

With regards to the issue of differentiating between basic and advanced user interactions, Activity Theory incorporates the idea of identifying contradictions or problems when analysing human activity. Contradictions (discussed in section 3.2.3, under 'Activity System') also portray the developmental aspects of the activity, by revealing new understanding about the activity being studied (Engeström, 1987; 1999). The existence of contradictions in human interactions with a computer system may imply on one hand that, the user is not yet knowledgeable or confident about using the system, whilst on the other hand; it may also suggest that the design of the system is not suitable for the task and user's objective.

The idea of identifying contradictions in an activity is also significant to the conceptualisation of relational differences and similarities that may exist *within* and *between* user interactions. Differences and similarities in user interactions may be associated to users' motives for engaging in activity. The system designer therefore needs to understand the users' motives for carrying out a particular activity. This can also reveal the reasons behind the existence of relational differences and similarities in user interactions. It is also important to understand how these relational differences and similarities influence developments in that activity so as to make sense of the changes that may occur.

Challenge: Need to reflect user input in design

Design issues raised:

- How to identify the relevant user interactions to focus on?
- What sort of data to gather about potential users of the proposed system and their tasks e.g. should the designer include the study of the psychological aspects of the user and tool use?
- How to gather data about user tasks, needs, and, also their knowledge about using the system?

Activity Theory Perspective:

In order to identify relevant user interactions to focus on when analysing human activity, Activity Theory suggests that the designer needs to deal with specific activities (Leont'ev, 1978). The systems designer therefore needs to identify and select specific activities from the main activity systems to focus on during a detailed investigation. This point is well illustrated in Leont'ev's (1978) notion of activity, in which he exemplifies the constituent components of an activity whilst also showing the various levels of operation.

With regards to the issue of deciding on the kind of data to gather about potential users of a system, Activity Theory does not give any specifications on this. Instead, it emphasises the idea that data gathered should reflect users' objectives for carrying out activity. In addition, data gathered should also reflect the social and cultural perspectives of the context in which activity is carried out. Furthermore, Activity Theory recognises the complexity of human information processing. This is illustrated in the principle of consciousness, which emphasises the importance of investigating the intentions and motives of those involved in the activity being studied. These intentions and motives are to be understood from a social and cultural perspective in context. From the HCI design point of view, studying human intentions and motives in context means the user's opinions and established ways of doing things becomes a primal concern during the design process.

The actual process of gathering data about users is not stipulated. As illustrated by Nardi (1996), Activity Theory does not give already made methods for collecting and analysing user data. Instead, it recommends the use of various data collection techniques and methods during the investigation. In the meanwhile, the data gathering process ought to be a prolonged period of research carried out in the environment in which activity naturally occurs. A prolonged period of research would enable the researcher to understand the historical developments and transformations of the activity being examined. In practice, this means using ethnomethodological approaches to investigate the historical developments and transformations of an activity at various levels of analysis.

Challenge: *Need to incorporate user involvement in design*

Design issues raised:

- How to define the user group (whether to work with a single user who is a domain expert or multiple users)?
- The designer needs to consider the level of contribution to be expected from users. For example, the design team needs to decide whether users will be involved on full-time basis as part of the design team, or on part-time basis as consultants in the system's development process.
- There is a need to establish how much power to give users during systems design. Establish who has the final say on what gets implemented into the system.

Activity Theory Perspective:

Activity Theory's position with regards to the definition of the user group requires the involvement of real users in the design process. The idea of using a domain expert (see section 2.2.2 in chapter two) for consultation purposes or to represent end-users on the design team is therefore in conflict with the Activity Theory's philosophy on studying human activity. According to Activity Theory, individual actions cannot accurately represent collective practices (Engeström, Miettinen and Punamäki, 1999).

“Individuals act in collective practices, communities, and institutions. Such collective practices are not reducible to sums of individual action; they require theoretical conceptualisation in their own right” (Engeström and Miettinen, 1999, page11).

The idea of generalising individual perspectives and observations on activity, as is the case when using a domain expert can cause problems when trying to understand activity in a collective context. Human behaviour cannot be accurately predicted.

The researcher is therefore encouraged to involve real end-users in the design process, and also to carry out the study in the users' work place.

When considering the level of contribution to be expected from users, Activity Theory is flexible enough to be able to accommodate any research methods that the designer may wish to use when applying concepts. It is therefore left open to the researcher to decide on the level of contribution and involvement to be expected from the user. The main point to note here is that Activity Theory emphasises studying work practices in the environment in which activity occurs for a prolonged period of time. At the same time, the analysis of user activities should be perceived from the users' point of view. Therefore, in situations where users are not actively involved in data gathering, for example, when using observational methods, users can participate in the design process by interpreting and clarifying issues for the system's analyst.

In terms of establishing how much power to give users during systems design, Activity Theory here again is not specific. As mentioned before, Activity Theory does emphasise that the analysis of user practices ought to be understood from the users' point of view. This implies that decisions on what gets implemented into the system should reflect user opinions. The researcher therefore needs to negotiate and clarify design decisions taken with the users.

Challenge: *Need to focus on usefulness*

Design issues raised:

- How to make research findings bear on design (i.e. how to communicate findings to systems developers)?
- Whether to test the usability of the system at the users' or developers' work place?
- How to interpret data gathered about user tasks, and also how to validate design representations so as to produce a useful systems?

Activity Theory Perspective:

In order to make research findings bear on design, the flexibility afforded in Activity Theory means that the designer can easily use other approaches to communicate their understanding of the activity under investigation. The communicated insight ought to portray a holistic perspective of the activity situation. For example, if the designer uses certain notations to communicate their understanding of the user's activity during design, then those notations should represent a holistic view of what is happening. In addition, both the user and the systems developer should easily understand the notations used.

Activity Theory's position with regards to the issue of testing the usability of a system is that, it should be conducted in the environment where activity normally takes place. Activity Theory focuses on establishing the best ways to support the subject in their efforts to achieve targeted objectives. This is reflected in the framework's emphasis on the need to develop tools that help the user to achieve desired goals and objectives. The Activity Theory approach is committed to understanding and judging the usability and usefulness of a computer system from the users' points of view. The importance of this idea is also reflected in the suggestion to use ethnomethodological techniques when analysing human activity so as to get the 'natives' point of view on what works and what doesn't in that particular context.

The task of interpreting data gathered about user activities, and also the validation of design representations finally produced to communicate that insight needs to reflect users knowledge about the activity being carried out. A close collaboration and consultation between the designer and users can therefore yield meaningful insights that may result in the production of a useful system for intended users.

Challenge: *Need to understand the user and context of use*

Design issues raised:

- How to account for the work culture and organisation of the context of deployment for the system being built?
- How to handle variations in the objectives of stakeholders (users, system designers etc) on the design team?
- How to account for variations in work patterns of collaborating potential users of a computer system?

Activity Theory Perspective:

The idea of understanding the user and context of use for a system being built is important in Activity Theory. The designer is therefore encouraged to take a holistic approach to analysing human activity. In practice, this implies establishing and accounting for the various social-cultural and contextual issues that stand to influence the users' judgement on the usefulness of a computer system.

On the issue of handling variations in objectives of stakeholders on a design team, Activity Theory recognises that human beings working on the same activity could have different motives for engaging in activity. Therefore, Activity Theory puts particular emphasis on establishing and focusing on the main objective for that activity. The main objective is common to all participants and connects the various individual motives for engaging in activity. Focusing on the main objective of a design activity is vital for establishing the means by which motives influence individual's decisions and behaviour. In turn it is also important to understand how individual decisions and behaviour relates to other peoples' actions within the same environment and also how they affect the overall (shared) objective of that activity.

In order to account for variations in work patterns of collaborating potential users of a computer system, the designer needs to examine broader patterns of the activity being investigated. This way, the designer can grasp the overall picture of the situation in which activity is carried out. At a more practical level, this entails analysing activity at various levels of abstraction (Leont'ev, 1978) so as to establish the kind of local patterns and relationships that exist *within* and *between* the observed broader patterns of activity. A more fine grain analysis of these broader patterns can help to uncover local structures of activity that may reveal local cultural basis for the displayed behaviour. Local patterns of activity tend to be unique or exist in their own right but at the same time, they are part and parcel of broader patterns of the main activity.

3.6 Conclusion

The last two chapters (chapters two and three) of this thesis concentrated on exploring systems design perspectives from both the HCI and Activity Theory point of view. Chapter two investigated HCI design methods, whilst chapter three examined the Activity Theory conceptual stance in relation to HCI research and practice. A critical analysis of HCI methods in relation to the identified design challenges and issues raised reveals two diverging themes to systems design. These themes are such that whilst some of the methods studied are focused on enabling the designer to conceptualise the structure of computer users' activity – task oriented methods; others emphasise the analysis of the cognitive aspects of computer tool users or subjects engaged in activity. In the meanwhile, the Activity Theory conceptual stance highlights the significance of addressing both perspectives during systems design since both the task and subjects, implicitly and explicitly transform each other during activity. Given this stance, the main challenge for HCI design is to establish a Method for putting into practice this dialectic process when gathering, analysing and communicating systems design requirements. This approach to HCI design enables the systems designer to holistically conceptualise the mutually transforming relationships between what is being done – the task or activity, and, those doing it – the human subjects, in context. A key aspect of this process would

be to establish how doing one changes and affects the other. The next chapter (Chapter Four) will therefore investigate how to put Activity Theory concepts into practice in order to meet the outlined challenge for HCI design.

Chapter Four

4. Operationalising Activity Theory

This chapter serves as a bridge between the literature review chapters presented in two (HCI) and three (Activity Theory), and, chapters that describe the empirical work carried out as part of this research (chapters five, six and seven).

In chapters two and three, I evaluated some of the user and design concerns that have raised focus on issues relating to the usefulness of computer systems. Key challenges and design issues currently being considered by HCI practitioners were identified following a review of HCI design methods in chapter two. The identified challenges together with design issues raised were examined and discussed from an HCI point of view in chapter two, thereafter, from an Activity Theory perspective in chapter three. On reflection, it seems HCI design could benefit from Activity Theory's holistic and dialectic approach to analysing the transformative relationship between users of a computer system and the activity in which they are engaged. Given this stance, the natural progression for the foregoing discussions is to establish the means by which the concepts presented in Activity Theory can be incorporated into systems design. This chapter therefore, considers the feasibility of operationalising¹ Activity Theory for HCI design purposes. This investigation resulted in the development of the AODM, - a structured Activity Theory based method for HCI research and practice.

Chapter four therefore begins by reviewing literature on approaches to putting Activity Theory ideas into practice. Within these discussions, I will review some of the prominent researchers' recommendations for operationalising Activity Theory.

¹ The terms, 'operationalise', 'operationalising', or 'operationalised' 'operationalisation' are used in this thesis to refer to the practical or active process of putting Activity Theory concepts into practice.

My main reading here is based on writings of Nardi (1996), Engeström (1993 and 1999), and, Bødker, (1996). These discussions will be continued by reviewing some of the practical attempts made so far to provide a method for operationalising Activity Theory in HCI design. Here I will review the works of Kaptelinin and Nardi (1997), and also, Korpela, Soriyan and Olufokunbi (2000). Thereafter, I will draw conclusions from foregoing discussions and move on to present the context and background to the development of the AODM being proposed in this thesis.

4.1 Overview

The ideas presented in Activity Theory enhance and extend the practical concerns about the usefulness of computer systems, which are traditionally addressed by the HCI discipline. Activity Theory achieves this by linking design solutions to social, cultural and psychological aspects of computer tool users in context. The Activity Theory conceptual approach to systems design highlights the importance of computer users' social and cultural behaviour revealed during activity as human beings interact with objects of the environment. Given this stance, it seems to be the view that by analysing human activity in context, using this framework, computer systems developers can fully account for the often complex and intertwining issues that impact on the usefulness of these tools.

4.2 Methodological Considerations

Whilst the ideas presented in Activity Theory sound promising by providing a robust analytical framework and also a much-needed common vocabulary for describing human activity in context (Nardi, 1996); there is no established standard method for putting Activity Theory concepts into practice (Nardi, 1996). As noted by Engeström (1993), Activity Theory does not offer ready-made techniques and procedures for research. Instead, Activity Theory provides conceptual tools that must be applied according to the specifics and nature of the objective of the activity under scrutiny. The lack of a standard method for applying Activity Theory within HCI could be attributed to the fact that there are several basic principles of Activity

Theory (Kaptelinin, 1996) on which an investigation method could be based. Some of these basic principles have already been discussed in chapter three of this thesis (see section 3.3). In addition, Activity Theory as a framework, is continuously evolving. As a result of this, early efforts to operationalise concepts of Activity Theory focused on providing general practical guidelines and recommendations for using Activity Theory during research. For example, Engeström (1993) describes three principles of Activity Theory that are crucial for consideration when operationalising Activity Theory concepts. These three principles are discussed as follows: -

- 1) The first principle identifies the need to focus on and use a *collective activity system as the unit of analysis*. In practice, this requirement raises issues relating to where to draw the boundary or how to identify the collective activity system from the environment of study. In addition, once the collective activity system has been established, there is also the task of identifying components and attributes of the collective activity system.
- 2) The second principle highlights the significance of *identifying both internal and external contradictions* (discussed in section 3.2.3 under ‘the Activity System’) ‘*within*’² and ‘*between*’³ the various components of the collective activity system when analysing data gathered. According to Engeström (1993; 1999), contradictions form the basis for the acquisition of new understanding about the activity system being investigated. He further explains that contradictions are manifested as disturbances or conflicts whose investigation is necessary in order to understand innovations and the kind of changes that are taking place in the activity system being studied.

² The italicised term ‘*within*’ is used in this thesis to refer to Activity Theory based analysis of activity relationships inside a single component of the ‘collective activity system’.

³ The italicised term ‘*between*’ is used to refer to Activity Theory based analysis of relationships involving two components of the ‘collective activity system’.

The importance of identifying contradictions when analysing data from an Activity Theory perspective is also reflected in Bødker's (1996) approach to studying artefacts-in-use. In her approach to analysing video data, Bødker, emphasises the need to understand the use situation as being crucial to the continuation of the development of HCI methods on which design must be based (page 147). In this regard, understanding the use situation entails identifying breakdowns in computer use. In practice, breakdowns manifest themselves as contradictions or unexpected problems that occur when using a computer system. The resulting effect is that the computer behaves in an unexpected way, thereby triggering a change or shift in user focus. Instead of focusing on the objective of the activity at hand, the user pays attention to operational mechanisms of the tool so as to establish how to use it.

- 3) Thirdly, Engeström (1993) stresses the need to *analyse the historical development of the activity* being examined in the context in which activity is normally carried out.

Three years after Engeström (1993) alerted the Activity Theory research community about the lack of a specified method for applying Activity Theory, Nardi (1996, pp. 235-246) also made similar methodological suggestions on applying Activity Theory concepts to HCI design. In so doing, she identified and made four recommendations for operationalising Activity Theory concepts in HCI. These are described as follows: -

- 1) The first recommendation suggests that the *research time frame needs to be long enough to understand user objectives for engaging in activity*. Understanding user objectives entails establishing the kind of changes that occur in activity and the focused objective over a period of time. This conceptualisation includes relationships that exist *within* and *between* objects of the activity being studied. To operationalise this recommendation, Nardi (1996) suggests conducting investigations in a phased approach that consists of several steps. However,

Nardi doesn't explicitly outline methodological procedures to be incorporated in these steps.

- 2) In the second recommendation, Nardi suggests the need to *pay attention to broad patterns of an activity* rather than narrow episodic fragments so as to establish the overall direction of an activity. In practice, this recommendation refers to the need to establish the various links and associations that exist in an activity system especially where levelled abstractions and decomposition techniques are employed during analysis.
- 3) The third recommendation highlights the need to *use various data collection techniques*. These data collection techniques could include conducting interviews, carrying out observations, also the analysis of video and historical materials. Nardi (1996) further explains that the techniques used ought to be balanced so that the researcher does not depend so much on one method.
- 4) Finally but not least, the researcher needs to be committed *to understanding things from the users' point of view*. This implies getting users' feedback and clarification on emerging matters so that the investigator's interpretation of the activity reflects users' opinions about the examined activity.

The above general principles and practical recommendations for using Activity Theory go a long way towards providing insights into the means by which concepts from this framework can be operationalised. However, both Engeström (1993; 1999) and Nardi (1996) do not explicitly stipulate methodological procedures for putting these recommendations into practice when studying human practices. It is therefore up to each individual researcher to interpret the general recommendations and apply Activity Theory as they see fit. As a result of this flexibility, Activity Theory concepts have been interpreted and applied in various ways in different contexts. *This flexibility has introduced difficulties in replicating, comparing and criticising the approaches taken to operationalise Activity Theory.*

In addition, whilst this flexibility introduces certain design and research advantages, for example ease of integration with other methods already in use, it also adds difficulty to an already complex and heavily intertwined conceptual framework. This complexity has meant that the use of Activity Theory in HCI design has been limited to those practitioners who are knowledgeable in developmental psychology, or those researchers who have invested time to learn and interpret concepts of this complex theoretical framework for systems design purposes (e.g. Turner, Turner and Horton, 1999). Given the foregoing deliberations, the need for a structured and replicable method for applying Activity Theory concepts to HCI research and practice is imminent.

Others (Kaptelinin and Nardi, 1997; Korpela, Soriyan and Olufokunbi, 2000) have also recognised the necessity of making Activity Theory accessible and usable for systems design purposes. In this regard, Kaptelinin and Nardi (1997) pioneered this process by holding tutorial sessions at conferences to introduce basic principles of Activity Theory to HCI researchers and practitioners, thereafter to teach them how to apply these concepts during systems design. In an effort to introduce a standard approach for operationalising Activity Theory during systems design, Kaptelinin and Nardi (1997) developed an ‘activity checklist’ as a conceptual tool for operationalising Activity Theory (see also Kaptelinin et al., 1999). The ‘activity checklist’ has already been discussed in detail in section 2.2.11. The recognition of the need for a structured and replicable method for operationalising Activity Theory in systems design is therefore evident in the introduction of the ‘activity checklist’ by Kaptelinin et al. (1999). However, as mentioned earlier in chapter two, one of the key weaknesses of the ‘activity checklist’ from a methodological viewpoint is the lack of a clear mapping between the research questions presented and Activity Theory. It is difficult to visualise the relationships between Activity Theoretical concepts and the questions presented in the activity checklist. The significance of making the mapping between theory and practice explicit has been widely debated by various authors arguing for the need to demonstrate the transferability of theory

based methods into design practice, and also, the usability of these methods and models by practitioners (see for example, Buckingham Shum, Jørgensen, Aboulafia and Hammond, 1994; also, Rogers, 2001). I will outline the means by which I intend to address these issues towards the end of this section and also in the concluding part that follows this section.

Meanwhile, further efforts to produce an Activity Theory based method for systems design were made by Korpela, Soriyan and Olufokunbi (2000). Korpela and others explored the possibility of adapting already established Activity Theory based methods for studying work development into a day-to-day method for information systems practitioners. They attempted to draw parallels between Developmental Work Research methods exemplified by Engeström (1987; also, Engeström et al., 1999), and, less technical information systems development methods utilised during the early phases of systems design. In so doing, Korpela et al., based their approach on the premise that less technological areas of information systems development can use same methods as those utilised in Developmental Work Research (Korpela et al., 2000). Their main aim was to establish a method for using Activity Theory within information systems design that was based on Developmental Work Research methods. In their approach to operationalising Activity Theory for information systems design, Korpela et al. attempted to teach information systems developers and other stakeholders (e.g. intended end-users) on a health information systems project how to model and analyse activity systems as a way of conceptualising healthcare providers' work. In an approach similar to Kaptelinin et al.'s, Korpela and others also began by introducing basic principles of Activity Theory. They also presented a checklist incorporating a list of questions used to help participants identify the main constituents of the central activity (see Korpela et al., 2000, page 203). Thereafter, they demonstrated how to sketch activity systems as a way of elucidating participants' understanding of healthcare work practices during early phases of gathering requirements for a cooperative healthcare information system.

However, Korpela et al. discovered that, teaching systems developers and other stakeholders Developmental Work Research methods to support systems requirements capture was not a straightforward endeavour. To begin with, participants considered their approach to be too abstract (see Korpela et al., 2000, page 201). In addition to this, participants also “criticised some of the terms (e.g. ‘subject’, ‘instrument’) for being too artificial...” (page 204). Korpela et al. admittedly experienced further difficulties in applying activity analysis to computer professionals’ (designers) work, these included difficulties in identifying the tools and skills required (page 205). This experience led them to acknowledge the need for further research into the development of Activity Theory based methods that can be readily applied by systems designers.

“The crucial issue is whether the method is suitable to be applied in day-to-day IS projects by information systems professionals, without the presence of highly trained work development researchers or consultants. To that end, further action research is required in different kinds of full-scale IS development projects in which IS practitioners try the method in practice” (Korpela et al., 2000, page 207).

In their approach, Korpela et al. presented empirical illustrations of how they used Activity Theory based on Developmental Work Research methods during the early phases of systems development. Here they utilised examples from a case study to describe ways in which Activity Theory can be used to support early phases of developing a health information system. Whilst the idea of providing empirical illustrations has the advantage of presenting demonstrable means for applying Activity Theory in systems design, it is difficult to visualise the structure, and also the mapping of Activity Theory concepts into practice in Korpela et al.’s (2000) approach. It is important to show traceable mappings between Activity Theory and design processes being supported in order to demonstrate the transferability of theory into practice. Korpela et al (2000) also recognise the significance of structure in a design method so as to facilitate ease of use. They concluded their study by highlighting the need for “illustrative examples and training materials” to support the application of Activity Theory in systems design.

“In conclusion, we argue that the experiments were, encouraging, but the method needs to be supported by further illustrative examples and training materials” (Korpela et al., 2000, page 191).

The lack of a clear structure for operationalising Activity Theory in systems design adds to the cognitive complexity in understanding and using the method, especially for designers who are not acquainted with Activity Theory literature. It is therefore, one of my key objectives to construct a structured and replicable Activity Theory based method for use in HCI design. The envisaged method will exemplify clearly the mappings between Activity Theory and the systems design processes being supported in an easy to follow and replicable manner. This will entail the presentation of a step-by-step description of the operational mechanisms for applying Activity Theory to systems design. This approach is demonstrated in chapters five, six and seven. Whilst these chapters (five, six and seven) are focused on producing a systematic method for operationalising Activity Theory in HCI design, discussions also simultaneously demonstrate the means by which the developed method can be used to support work analysis.

4.2.1 Conclusion

What is apparent from the above discussions about methodological considerations for operationalising Activity Theory is that both Kaptelinin et al. (1997 and 1999), and, Korpela et al. (2000) found it necessary to incorporate introductions of theoretical basics of Activity Theory in their methods. Whilst, the idea of including theoretical basics is important for the purpose of introducing and clarifying underlying concepts, it can also raise usability concerns for systems designers. For example, to some systems designers this may imply that the method cannot generally be easily understood or used without learning the incorporated basics of the framework. Secondly, even if designers were to make an effort to learn these theoretical basics, it is not easy to determine when enough understanding or knowledge about basic concepts has been acquired to be able to use the method confidently. Whilst designers need to know about Activity Theory concepts in order

to use an Activity Theory based method efficiently, the dilemma is that, HCI practitioners also need design methods that can be readily applied into systems design.

However, putting theory into practice is not an easy task. The use of a theory to inform computer systems design requires the justification of the method used to operationalise the theoretical concepts, together with the provision of clear evidence of the mapping between theory and the design representation that is finally produced. To achieve this level of effectiveness in operationalising theoretical concepts, the method used ought to be replicable and well structured and more importantly grounded in the theory itself. Unfortunately as we have already established from foregoing discussions, such a method for operationalising Activity Theory does not exist. As a result of this, the role of Activity Theory in computer systems design has often been reduced to descriptions of the benefits begot as a result of using concepts from this framework without necessarily explaining how Activity Theory was applied.

In my approach, I will address these issues by developing a systematic and well-structured method so as to reduce cognitive complexity. This will be achieved through the envisioned method's incorporation of a technique to provide cross mappings between the underlying Activity Theoretical framework and the systems design processes being supported. This thesis therefore will demonstrate the means by which Activity Theory can be used both as an analytical tool for conceptualising and describing human practices in context, and also as a practical tool for guiding the systems design process. It was this desire to demonstrate the practical aspects of using Activity Theory to inform systems design, which inspired the development of the 'Activity Oriented Design Method' (AODM), - a structured and theoretically grounded practical method for HCI research and practice.

The section that follows hereafter outlines the context and background to the AODM development and application procedure.

4.3 Context for developing AODM

The context for the development and evaluation of the Activity Oriented Design Method (AODM) being proposed in this thesis involved two organisations participating on a European funded research and development project – the Enrich⁴ project. The Enrich project was funded by the European Union (EU) under ESPRIT to develop computer tools and methods for integrating working and learning within knowledge intensive organisations (Sumner, Domingue and Zdrahal, 1998). This project consisted of a consortium of six partners. Of the six partners, three were academic institutions, whilst the remaining three were industrial organisations from EU member states. The Knowledge Media Institute (KMi) at The Open University was the UK academic partner on the consortium. The Enrich project was managed and co-ordinated by KMi at the Open University. This arrangement enabled me to gain access to the industrial partners for the purpose of carrying out this study. Further information about specifics of the Enrich project will unfold as we progress into ongoing discussions about AODM development and application procedure.

In order to satisfy Activity Theory's emphasis on studying artefacts in context, empirical work was carried out for over a period of two years in two organisations that formed part of the Enrich project. This approach enabled me to develop an empirically grounded method for operationalising Activity Theory. AODM was therefore developed iteratively and evaluated continuously in the context of analysing work practices in these two organisations, where both organisations were about to introduce the computer-based – Enrich system to support the management and nurturing of knowledge sharing activities. This situation provided a context for the study and enabled me to gather data. Within the framework of putting Activity

⁴ 'Enrich' is the name of the project. Detailed information about the Enrich project can be found on this web site -<http://kmi.open.ac.uk/projects/enrich/> (Nov, 2001). The term "Enrich system" - is used to refer to the computer system or tools developed as part of this project. The two organisations mentioned in this thesis were simply used as test beds to allow the author to conduct necessary empirical studies for this research. The author was not required to contribute to the design of the Enrich system or tools that were subsequently developed on the Enrich project.

Theory concepts into practice, the study had set out to understand work practices in the two case study organisations from a social and cultural perspective. This entailed establishing the means by which work practices naturally occurred together with the support mechanisms, which were in place prior to, during, and following the introduction of a computer system. Work practices in these two organisations were analysed as continuously developing processes that transform human activity. Activity Theory's notion of tool mediation was crucial to this analysis due to its emphasis on the idea that human capacities develop in collaboration with other individuals, by interacting with their environment. This interaction involves the use of tools whose development and usage is influenced by the social-cultural settings of the environment in which activity is carried out (Vygotsky, 1978; Leont'ev, 1981).

Figure 6 illustrates the AODM development and application procedure.

4.3.1 AODM Development and Application Procedure

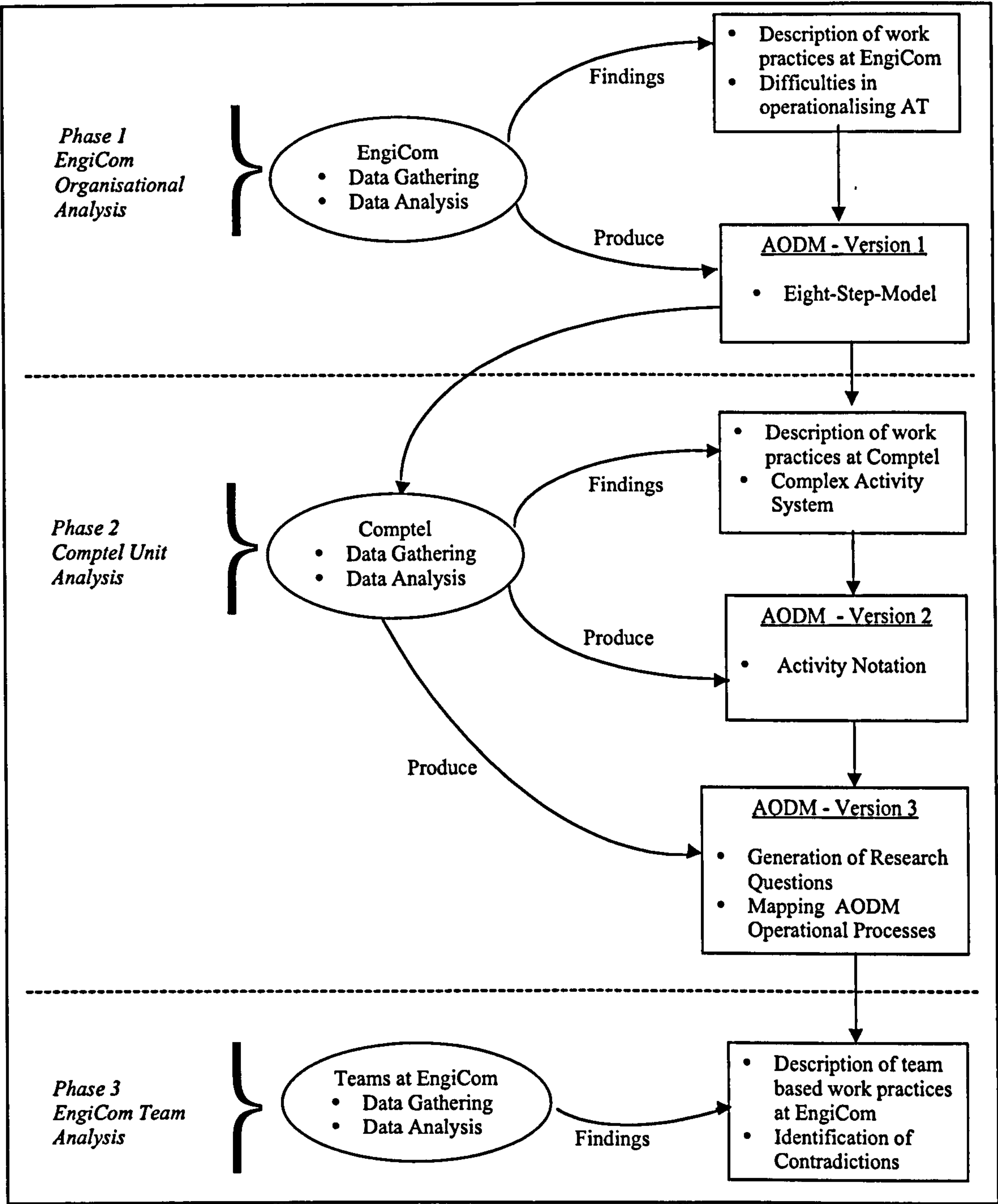


Figure 6: AODM development and application procedure

The two organisations used in this study will be referred to using pseudonyms as follows: The first organisation has been renamed as EngiCom - a UK based engineering company. The second organisation will be known as CompTel - an industrial computer systems development and applications support organisation based in Germany. The study was conducted in three phases over a period of two years. Figure 6 presents a diagrammatic illustration of the AODM iterative development and application procedure. The figure outlines findings of the analysis of work practices in each one of the three-phases whilst at the same time outlining AODM tools produced. Details of AODM development and application procedure presented in Figure 6 are discussed in chapters five, six and seven. These are introduced as follows.

- *Phase 1* of the AODM development and application procedure illustrated in Figure 6 will be discussed in detail in chapter five. Chapter five begins by considering possible approaches for operationalising Activity Theory to study work practices in the first organisation - EngiCom. Thereafter, discussions of initial analysis of work practices at EngiCom are presented. This initial analysis was conducted at management level. This investigation included the establishment of support mechanisms or mediators that were in place. The analytical aim of this initial study was to obtain a general overview of work practices in this organisation prior to the introduction of the Enrich computer system. The methodological output of this phase was the development of the *Eight-Step-Model* shown under 'AODM - Version 1' in Figure 6.
- *Phase 2* of the AODM development and application procedure reflected in Figure 6 will be discussed in detail in chapter six. Chapter six describes the analysis of unit based work practices in the second case study organisation - CompTel. The 'Eight-Step-Model' (see Figure 6) developed in Phase 1 was used during the analysis. The main reason for conducting this part of the study in a different organisation was to provide a comparative perspective to the analysis. In addition, this approach made it possible to apply and evaluate the AODM tool

developed in Phase 1 in a different context. Output of this analysis includes findings relating to the usability of the Eight-Step-Model, which resulted in the production of additional method tools. Additional AODM tools that were produced in Phase 2, includes the *Activity Notation*, the technique for *Generating Research Questions* and also the technique for *Mapping AODM Operational Processes*. In Figure 6, these method tools are shown under ‘AODM - Version 2 and 3’.

Therefore, a complete suite of AODM tools was developed by the end of what is portrayed as Phase 2 in Figure 6. Chapter six therefore marks the end of discussions describing the development of AODM tools. Chapter seven concentrates on describing how the various AODM tools can be applied when studying work practices.

- *Phase 3* of the AODM development and application procedure presented in Figure 6 will be discussed in detail in chapter seven. Here I will present the second analysis of work practices at EngiCom. This investigation revisited EngiCom to conduct a more detailed and focused study of work practices this time at team level following the introduction of the Enrich system. Discussions of this second study present a detailed analysis of team based work practices in this organisation. During the study, the complete suite of AODM tools developed in ‘AODM – Versions 1, 2 and 3’ were used when studying work practices at team level. The re-analysis of work practices in the same organisation from two different perspectives enabled the investigation to obtain both management’s and workers’ viewpoints on work activity. This approach made it possible to compare the conceptualisation of work practices established at two different operational levels; namely management level as discussed in chapter five, thereafter team level as illustrated in chapter seven. This analytical approach made it possible to respond to emerging issues with regards to the application and usability of AODM. As a result, AODM tools were iteratively

developed in one context, thereafter applied and evaluated in another so as to assess and validate the generalisability of these methodological tools.

4.4 Summary

This chapter has reviewed the various recommendations put forward for operationalising Activity Theory. The main problem observed was the lack of standard method for putting these recommendations into practice. In systems design, the significance of a method for operationalising Activity Theory is evident in the increase in research efforts to produce Activity Theory based tools and methods (see for example, Kaptelinin et al., 1999; also Korpela et al., 2000). However, a critical review of the methods and tools introduced to operationalise Activity Theory has highlighted a number of problems associated with these approaches, these include the lack of a clear method operational structure. This makes it difficult to understand and use the method. In addition to this, the mapping between theory and design is not made explicit in the reviewed methods and tools.

The next three chapters (five, six and seven) will discuss how AODM addresses these methodological issues raised, by systematically describing in detailed how and why the various tools incorporated in AODM came to be developed. Discussions in these chapters will simultaneously explain how AODM tools were used to inform systems design processes of gathering, analysing and communicating insights about work practices in the two case studies. For this reason, I strongly recommend that these three chapters (five, six and seven) be read consecutively as a block so as to fully comprehend:

- The reasons behind the constructions of the tools
- How the tools were actually developed
- How the developed tools can be used to support design.

These issues are explicated in two case studies that provided a platform for studying the *social and cultural*, *motives*, *relationships*, and, the *history* of the development

and use of tools to mediate⁵ human activity in those *contexts*. The studies were conducted during the early stages of systems design as part of systems requirements capture.

The section that follows summarises foregoing discussions by describing the empirical data gathered as part of the practical research carried out.

4.4.1 Data Summary

The description of empirical data, which forms part of the two case studies presented in the next three chapters (chapters 5, 6, and, 7) is summarized as follows.

In order to gather empirical data during the research, I carried out two case studies involving two organisations. Detailed information about individual case studies will be progressively given in chapters 5, 6, and, 7. The two organisations used in this research were analysed in three separate phases (phase 1, 2, and 3) as indicated in Figure 6 (see section 4.3.1). During the study, semi-structured interviews were conducted with selected workers. I also carried out some observational studies of work practices whilst workers carried out their duties. In both approaches, I used identified research questions prepared in advance as reminders on the kind of issues to ask about during the interview. I also used identified questions as pointers to issues to look for during observational studies. The questions were open-ended and I did not follow them systematically so as to give the participants increased flexibility when responding. I therefore did not give these questions to participants to read and answer. In addition to this, I did not record the duration for conducting interviews so as to maintain an open-plan interviewing style whereby respondents would be free to leave and re-join the interview schedule. I introduced this kind of flexibility in the interview strategy so as to make the interview less formal. The interviews and observational studies were carried out in the two organisations' sites of operation. This contextual approach to studying work practices in an organisation meant that

⁵ Mediation or 'mediate' has already been discussed in section 3.3.2

several visits were made to each organisation's operational site to conduct observational studies and semi-structured interviews in context. The duration of these visits varied from one day long regular visits to long term visits involving several weeks of on-site study. I used an ethnographic approach to gathering data. This meant that I was immersed in the cultural practices of the case study organisations both on and off site. On site, I conducted observational studies and semi-structured interviews with selected members of the work force and senior staff. Off-site, I browsed through the company intranet and internet systems; participated in online discussions with workers via intranet based company newsgroups; also communicated with key workers via telephone and email. In addition to this, I gathered information about work practices in the two case study organisations by analysing company CD-ROMs and company documentations containing classified information about work operations.

In terms of recording data sources, I was unable to tape record conversations or interview proceedings with workers due to copyright restrictions. Both organisations had restrictions on the circulation and use of classified company information. As a result of these restrictions, I am unable to include direct commentaries from observational studies and unofficial discussions carried out with workers during the study. Neither am I able to present extensive extracts of direct quotes from conducted interviews with workers. Therefore, the description of empirical work presented in the next three chapters does not include extensive extracts of direct quotations from empirical investigations of work practices in the two organisations. Therefore, in order to give the reader some insight into the data gathering process and source of empirical data, my own interpretations of raw data are included in the appendices of this thesis (see Appendix A and B).

Empirical data presented in this thesis mainly consist of field notes written by the researcher during the study. These field notes consist of my own personal reflections on the method to use when analysing work practices using Activity Theory. In addition to this, the field notes also reflect personal interpretations of data gathered

following each visit (as an after event reflection) so as to verify the correctness of the information gathered.

Detailed discussions about empirical investigations carried out during the research are presented in the next three chapters (chapter 5, 6, and, 7).

Chapter Five

5. AODM Development Phase 1 - EngiCom Study

The previous chapter (Chapter Four) reviewed some of the practical recommendations (Nardi, 1996; Engeström, 1993) and design approaches (Kaptelinin et al., 1997; Korpela et al., 2000) suggested for putting Activity Theory into practice. Discussions later highlighted the need for a structured and replicable Activity Theory informed method for use within HCI design. This chapter (Chapter Five) reports on the empirical development and application of such a method – the AODM, using the first case study organisation – EngiCom. Chapter five is therefore focused on describing practical experiences of using Activity Theory to study work practices at EngiCom, an activity that resulted in the construction of one of the tools incorporated in the AODM - the ‘Eight-Step-Model’.

From the HCI design point of view, the decision to use Activity Theory both as a practical and conceptual tool presented the following methodological challenges that I will address in this chapter:

- 1) *How to gather data about work practices at EngiCom using Activity Theory?*
This Method challenge is addressed in section 5.1 and 5.2.
- 2) *How to analyse data gathered about work practices at EngiCom using Activity Theory?* This method challenge is addressed in section 5.3.
- 3) *How to model or communicate insights obtained about work practices at EngiCom using Activity Theory?* This method challenge is addressed in section 5.4.

This chapter therefore begins by exploring possible approaches for using Activity Theory to study work practices at EngiCom. In this regard two approaches were considered with their practicalities evaluated. The first approach considers the selection and use of certain concepts from the Activity Theory framework, whilst the second approach explores the possibility of using Engeström's activity triangle model as a unifying representation for Activity Theory concepts. The selected method was then used to guide the data gathering process. Following this section is a general description of EngiCom organisational structure and work practices. Thereafter, the approach taken to analyse data gathered is illustrated. This leads into discussions relating to the communication of acquired insights about work practices at EngiCom through modelling this organisation's activity system. Within these discussions, experiences and challenges of using the activity triangle model to empirically study EngiCom work practices are addressed. These experiences and challenges resulted in the conceptualisation of innovative methods for operationalising Activity Theory using the activity triangle model. Finally, the Eight-Step-Model is presented.

The process of analysing work practices at EngiCom therefore had two outputs. The first output presents findings of the analysis of work practices in this organisation at a general level. The second output outlines methodological considerations for applying Activity Theory to work analysis. These methodological considerations inspired the development of the 'Eight-Step-Model'.

5.1 Using Activity Theory to study EngiCom

The process of operationalising Activity Theory commenced during the first empirical study of work practices at EngiCom organisation. The aim of this initial study was to try and acquire a general understanding of the means by which work practices occurred in this organisation. Within this remit, the study was also trying to establish the support mechanisms that were in place for the execution and management of work practices in this organisation using Activity Theory. Therefore, the initial concern in this regard was

to construct a method for putting Activity Theory concepts in practice. Such an Activity Theory based method was required to aid the process of gathering and interpreting data so as to make sense of what was happening in this organisation. Since there is no established standard method for using Activity Theory (Nardi, 1996) within HCI, a decision was made to develop the method whilst analysing work activity in this organisation.

In order to generate a workable method to operationalise such a complex framework in relation to HCI design, two approaches were considered. The initial idea was to select suitable concepts from Activity Theory that were deemed relevant to work analysis and computer systems design. However, the idea of selecting and focusing on particular concepts did not seem very practical given that Activity Theory concepts are highly intertwined. It was difficult to decide which Activity Theory concepts to use and which to leave out. The complexity of the framework, and also the interconnectedness of the theoretical concepts indicated the need for a unified representation to aid the process of operationalising these concepts. I believe that this unification of Activity Theory concepts is realised in Engeström's (1987) expanded model of human activity – the 'activity triangle model' or 'activity system' (see Figure 5 in 3.2.3). Given this stance, the second idea considered for operationalising Activity Theory was to use the activity triangle model as a unifying analytical and practical tool for operationalising Activity Theory concepts. The key deciding factor here was to employ a method that would guide both the data gathering and data analysis processes of systems design. The envisioned method would also facilitate the interpretation and transfer of analysis results into a design representation with structure and continuity. The importance of structure and continuity in the method applied meant that the initial idea was rejected in favour of the second idea, which involved use of the activity triangle model. The activity triangle model offered a useful starting point because it seems to capture and unify key concepts from Activity Theory that are relevant to work analysis and tool design, whilst giving a structured approach to the analysis. In addition, the fact that the activity triangle model

incorporates various components of the human activity system implies that it was possible to employ an analytical decomposition technique to manage complexity during the investigation. This would facilitate levelled abstractions when analysing work activity. The activity triangle model also appeared to be an obvious candidate as it had already been applied to the study of technology and work practices (Bødker, 1996; Engeström, 1999; Blackler, Crump and McDonald, 2000). Furthermore, I realised that using this model to operationalise Activity Theory would help to put the study into the social and cultural context of the community in which activity is carried out. At the same time, this approach can enable systems designers to pay attention to the mediating aspects of the activity being examined through the tools, rules and division of labour components of the model. Therefore, by encompassing and unifying the various perspectives outlined above, the activity triangle model helps to address the key points from Activity Theory considered crucial to this thesis as outlined in section 3.1 (see Table 3).

However, operationalising Activity Theory using the activity triangle model was not a straightforward undertaking. Even though several researchers had used the activity triangle model to study human practices (Engeström, 1999; Blackler et al. 2000) for systems design purposes (Turner et al., 1999), there is no record of a systematic description of how to use it. Despite the lack of an established method for operationalising the activity triangle model, the idea of using it in this study was not abandoned. This was due to the fact that the model's unification of Activity Theory principles and identified key points (Table 3 in section 3.1) was considered a strong enough concept that helps to holistically bring the richness of this framework to the analysis of work practices for design purposes. Having made this decision, there still existed the predicament of establishing exactly how to use the activity triangle model to aid data gathering and analysis during the study. Since it was not immediately clear how to use the activity triangle model when gathering data, decision was made to initially

restrict its use to the communicative aspects of design. This meant that the activity triangle model would only be used to aid the task of modelling the various components of EngiCom's activity system. From the systems design point of view, the idea of modelling the EngiCom's activity system can help to establish and communicate the various components and mediators of the activity being examined. This decision meant that other Activity Theory compatible methods had to be employed to aid data gathering.

5.2 Data Gathering

Given that Activity Theory encourages the use of various methods from other frameworks during the investigation (Nardi, 1996), the use of ethnographic methods was considered for use during data gathering. However, as established earlier in section 2.2.8, the ethnographic approach does not provide methodological guidelines or explanations for studying artefacts or human activity in context. There are no guidelines as to how to look, where to look and what to look for during the investigation. The study was therefore still facing a methodological problem of how to use an ethnographic approach to aid data gathering. Despite this drawback, ethnographic type approaches to gathering data have advantages of bringing contextual and cultural orientations to the study. Contextual and cultural perspectives are some of the items highlighted in the key points identified to be crucial to this thesis (see Table 3). Detailed discussions that outline how data was ethnographically gathered during the study are presented as follows.

In order to ethnographically gather data for this study, I participated and shadowed on several Enrich¹ project meetings held between systems developers in KMi and representatives of EngiCom. During this process, general information about work practices and also the operational structure of EngiCom was obtained. Further

¹ Enrich was introduced in section 4.3. It is discussed in detail in section 5.2.2.

information about work practices in this organisation was gathered informally during tea breaks, organised project lunches and on other project activities whenever an EngiCom representative was present. These social gatherings made it possible to obtain a general understanding of the organisation's work practices and support mechanisms in less formal settings. In addition to this, a review of both paper-based and system-based company documents was carried out. Paper-based company documents reviewed included the 'company workbook'² and local reports. This includes other company publicity materials that were already in the public domain, for example, company financial reports and other products. System-based company documents reviewed included online reports and other communications conducted through Internet-based tools on the company web site. In addition, data was also gathered through the use of a 'proxy' (Plowman 1996). A 'proxy' is an individual with unrestricted access to various sources of information in the context of study. Plowman used the expression "ethnography by proxy" to refer to an interpretive approach to conducting work place studies in absentia. Ethnography by proxy therefore involves the use of a "proxy" or informant to collect focussed data on behalf of the researcher. This approach to collecting research data was developed to resolve difficulties in gaining access to classified information about artefacts, people, and work practices in natural settings. Plowman defends the validity of the 'ethnography by proxy' approach to gathering research data by emphasising that:

"Rather than agonise over the many ways in which research methods fall short of the requirements of ethnography, it is much more straight forward to acknowledge that restrictions on access to sites, to people, and to artefacts mean that the researcher will take a pragmatic approach in which various methods are used depending on which promises to be most rewarding" (Plowman, 1996).

² The idea of a 'company workbook' is discussed in detail in section 5.2.1.

In the case of the EngiCom study, the proxy was one of the company representatives on the Enrich project. There were two individuals representing EngiCom on the Enrich project, one of whom kindly agreed to act as a proxy for the purpose of accessing information that could not otherwise be easily obtained due to restrictions from within the organisation. Despite the fact that I had been given reasonable access to various areas and levels of operation in this organisation (see section 4.3 and 4.3.1 in chapter four) for the purpose of conducting this study, it was difficult to get totally immersed in all cultural aspects of the organisation single-handed. There was a need to clarify issues so as to maximise my understanding of work practices in this organisation. This entailed cooperating and establishing close working relationships with workers and more senior employees of this organisation. The idea of using a proxy was therefore also found to be very helpful in clarifying and interpreting issues during the study so as to transform information gathered into knowledge. The information gathered about EngiCom organisation was interpreted as follows.

5.2.1 About EngiCom

EngiCom is a large manufacturing engineering company based in the United Kingdom (UK). They manufacture industrial equipment and body parts mainly for their customers in the aerospace industry. The company employs thousands of people at its manufacturing sites or what is usually referred to as 'plants' all over the UK. Manufacturing operations at these plants are organised in team structure. Team operations tend to be product oriented with employees working in various areas including engineering and assembling plane body parts, sales, marketing, personnel etc. In terms of division of labour within these teams, a team usually has a leader, who is responsible for or heads a team. Each team has a minimum of fifteen workers. The team leader reports to the line leader who in turn reports to the production manager and the hierarchy goes on. Figure 7 shows a diagrammatic illustration of work operations at EngiCom.

Hierarchical operational structure of EngiCom

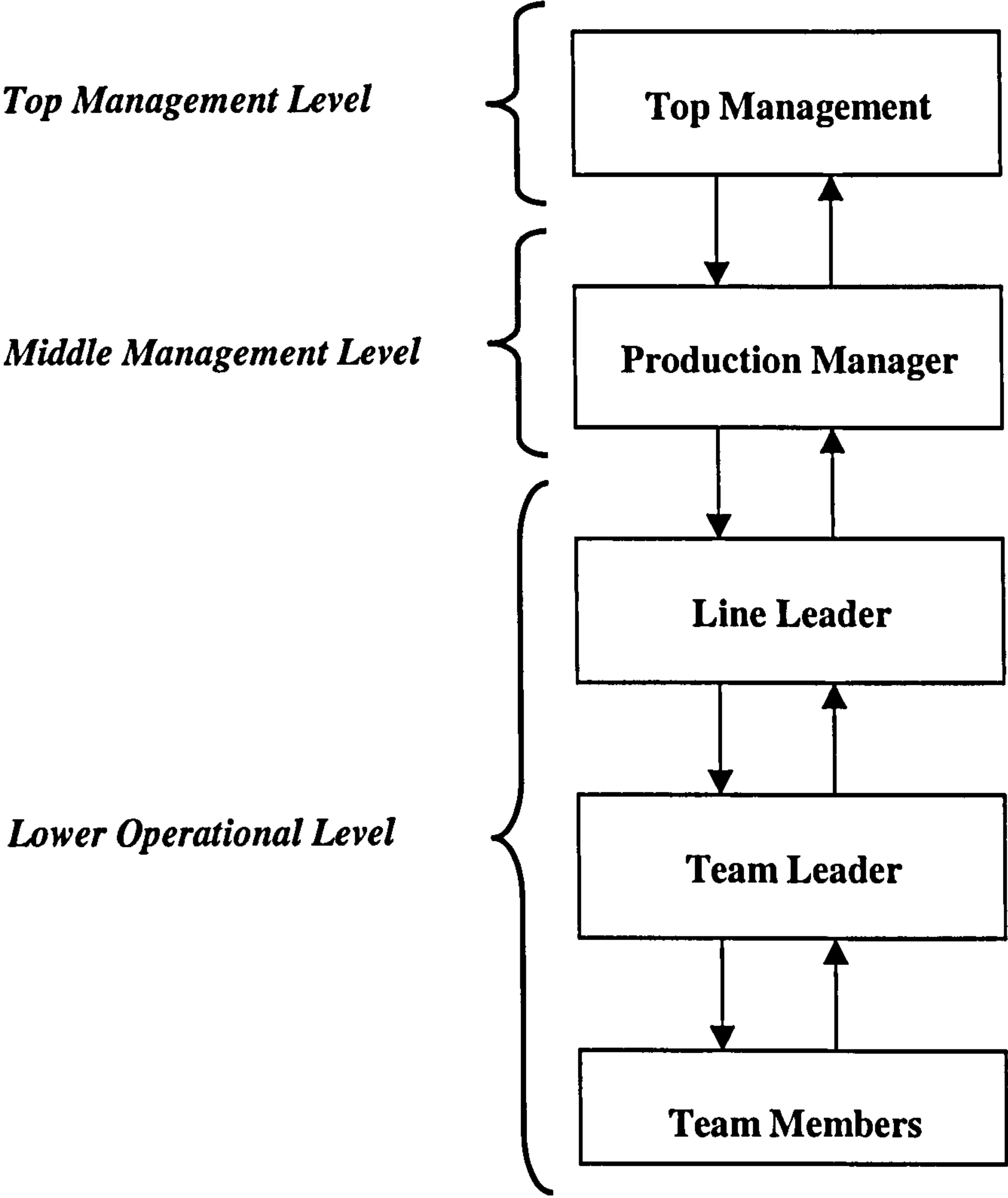


Figure 7: Operational Structure of EngiCom

EngiCom had a mission to become a trendsetter in the pursuit of excellence in the manufacturing and assembling of plane components within the aerospace industry. Satisfying this mission became a company goal. In order to achieve this goal,

management in this organisation identified *five company values* namely: Customers, People, Performance, Partnership, Technology & Innovation. These five company values were considered to be crucial to the successful attainment of the outlined mission. Company values established and defined practices and behaviour that underpinned the targeted mission. In order to sustain and reinforce the organisation's commitment to this mission, EngiCom had put into place a series of educational programmes to promote the understanding and application of company values to the organisation's operational and business environment. These educational programmes were implemented by organising workers in what was referred to as 'value teams'. Value teams were therefore based on the five company values. Workers in each value team were required to hold regular 'value-planning exercises'. During value-planning exercises, workers were required to set objectives to be met in relation to a particular company value and also reviewed their performances against previous targets previously set on that particular company value. Value-planning exercises were normally carried out during team meetings. In addition, workers were also encouraged to continuously reflect on their actions by evaluating their work practices during value-planning exercises as part of the educational programme. The rationale behind this was to encourage knowledge sharing amongst workers so as to enable workers to learn from each other's work experiences.

Management later introduced a '*company workbook*' as a paper-based work manual used to support workers in their day-to-day operations, also as a tool to guide the value-planning process. The company workbook provided a means for recording value-planning decisions and team performance evaluation activities through use of the *value-planning sheet* (Table 4) and *value-scoring matrix* (Table 5).

PLANNING SHEET

	OBJECTIVES	ACTIONS	MEASURES	WHEN (START AND END)	WHO
CUSTOMERS					
PEOPLE					
PERFORMANCE					
PARTNERSHIPS					
INNOVATION & TECHNOLOGY					

Workbook Dq, Issue 1, June '97.

Table 4: Shows a ‘Value-Planning Sheet’ (adapted from EngiCom Company Workbook)

The *value-planning sheet* (see Table 4, also Appendix B-10) was used for setting new objectives to be met in relation to the five company values. It incorporates the following features presented as labelled columns and rows in a table. The first column labelled ‘objectives’ was used for entering details of the objective to be met. The second column labelled ‘actions’ was used to record actions to be taken so as to meet the outlined objective. The third column labelled ‘measure’ was used for entering information about performance indicators (e.g. scoring matrix) to be used to assess whether not the objective set has been met. Thereafter, the fourth column labelled ‘when (start and end date)’ was used to record the duration for the implementation of the outlined plan. The last column in the table labelled ‘who’ was used to record identification details of those

involved in the execution of the value plan, for example, a team leader and other team members.

WHERE ARE WE NOW AGAINST OUR VALUES?

Read the descriptions against each value and mark the box you feel best reflects your current position. Repeat the exercise, indicating where you want to be. Agree a timescale.

						BY WHEN	COMMENTS	
Customers – Our highest priority	We have little or no understanding of who our customers are and what we provide to them.	We know our customers and the products and service we provide but have only an internal view of customer needs.	We understand customer needs which are documented. Measurement is rarely to these needs. We recognise the need for action but none are in place.	We have actions in place and measure performance to customer needs. Trend data is collected, is actively involved and we recognise the need for some agreement.	We have agreements with the customer, built around key areas, and regularly survey the customer's perception of our performance as part of our suite of measures.			
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			
	Partnerships – Our future	We have little or no understanding of who our partners are and what we provide to each other.	We know our partners and the product / service we provide to each other. We don't have any working relationship.	We have a working relationship with our partner. We have identified improvement actions but no measures to monitor progress.	We have agreement in place that sets the standards expected from each other. We regularly review with our partners and monitor performance to the agreement.	We have agreements and measures with our partners around key areas. We regularly review to identify areas for improvement.		
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
		People – Our greatest strength	We don't have skills and knowledge to meet our objectives. I can manage my team to deliver.	We have some awareness of our team's processes. We know what we do and how we do it as a team are different.	We only have trouble when two or three of the team are absent.	We meet our objectives and satisfy our customers' needs but we haven't learned to anticipate and meet their future needs.	Members of the team share skills and knowledge and team development is included in the plan which shows how they will be equipped to meet tomorrow's opportunities.	
<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			
Innovation & Technology – Our competitive edge	We do not encourage change to our processes. We don't see the need to change.		We have some ideas on how to improve, but are unsure how to implement them.	We actively listen to each others ideas and suggestions. Continuous improvement is recognised and rewarded within the team.	We are empowered to implement changes to our processes. We receive and share information on improvement ideas within and outside our team and Business Unit.	We take full advantage of technology to continually improve our efficiency. The team environment encourages the generation and explanation of new ideas.		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			
	Performance – Our key to winning	We are unaware of our team's processes. We have no measure of team performance.	We have some awareness of our team's processes. We know what actions the team could take to improve but we haven't created a plan.	We have documented processes. We have a prioritised team plan and recognise the need for measures to review progress.	We incorporate customer needs and supplier capabilities in our team plan. We use EQM to measure progress and results are communicated. We contribute to the Value Plan.	We have agreed sets of measures with customer. We regularly review our progress against the plan, which ensures we are always delivering business improvement. We clearly publicise our results.		
<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			

Workbook Plan, Issue 1, June '97.

Table 5: Shows the ‘Value-Scoring Matrix’ (adapted from EngiCom Company Workbook)

The *value-scoring matrix* (see Table 5, also Appendix B -11, on page 298) was used as a performance indicator so as to assess whether or not the objectives set in relation to a particular value had been met. This was established by entering two different markers on the sheet to indicate both the current and targeted level of performance in relation to a particular company value. For example, if a tick was used to indicate current level of performance in relation to the ‘customer value’, then an ‘X’ sign would be used to indicate the targeted level of performance on the same ‘customer value’ (see also Appendix B-8, on page 294). These markers were entered in smaller boxes positioned

underneath each row. On the left hand side of the scoring matrix are the five values. The value-scoring matrix also included a column for entering the review date. This was labelled 'by when'. Finally, the column on the far right hand side of the table labelled 'comments' was used to record general comments about the performance evaluation carried out.

These two sheets (*value-planning sheets* (Table 4) and *value-scoring matrix* (Table 5)) were incorporated in the company workbook together with other Total Quality Management (TQM) tools designed for teams with little or no prior TQM experience. According to management in this organisation, the company workbook stipulated more effective team working methods through the incorporation of these TQM tools. TQM tools outlined in the company workbook illustrated iterative steps to be followed by teams when:

- preparing a value plan,
- declaring and delivering the plan,
- reviewing and improving the plan.

It was management's view that these iterative steps provided a learning framework that enabled teams to secure continuous improvements in their sphere of responsibility. Using the workbook, local teams were able to identify their internal customers and suppliers, map out their key processes, measure their performances, and work collectively to secure higher performance levels and greater customer satisfaction.

The company workbook served as the main source of information about work practices during the study because it was presented by management as the official version of what happens in this organisation. A detailed evaluation of the company workbook was therefore conducted since it was the main guiding tool for the co-ordination and execution of work practices and collaborative knowledge sharing activities. Management's decision to introduce the use of a company workbook to guide the value-

planning process was an attempt to standardise the work planning and performance assessment procedures across all teams in the organisation. This standardisation initiated the process of formalising work procedures in this organisation. Management had hoped that this would encourage the sharing of knowledge about work across all teams throughout the organisation. The sharing of knowledge about work took the form of the accumulation of lessons learnt or what was referred to as 'best practices'. These best practices mainly consisted of work experiences of workers in other teams at various plants within the organisation. In the meanwhile, management had also recognised the benefits of using a computer system to support the process of managing and nurturing knowledge sharing activities as a means of promoting 'organisational learning'³.

5.2.2 The Enrich System

Since EngiCom formed part of the consortium on the Enrich project, management in this organisation requested that a computer system be built within the context of the project as an 'enhanced and enriched' version of the paper-based company workbook. The notion of 'enhanced and enriched' will be explain later in the discussion. In the meanwhile, a snapshot of the Enrich system introduced to support work practices at EngiCom organisation is presented in Figure 8 showing interface features of the system.

³ The term 'organisational learning' is used in this context to refer to knowledge sharing activities and processes that take places in work settings (Brown and Duguid, 1991). These include both formalised and unformalised work practices (Argiris and Schön, 1996).

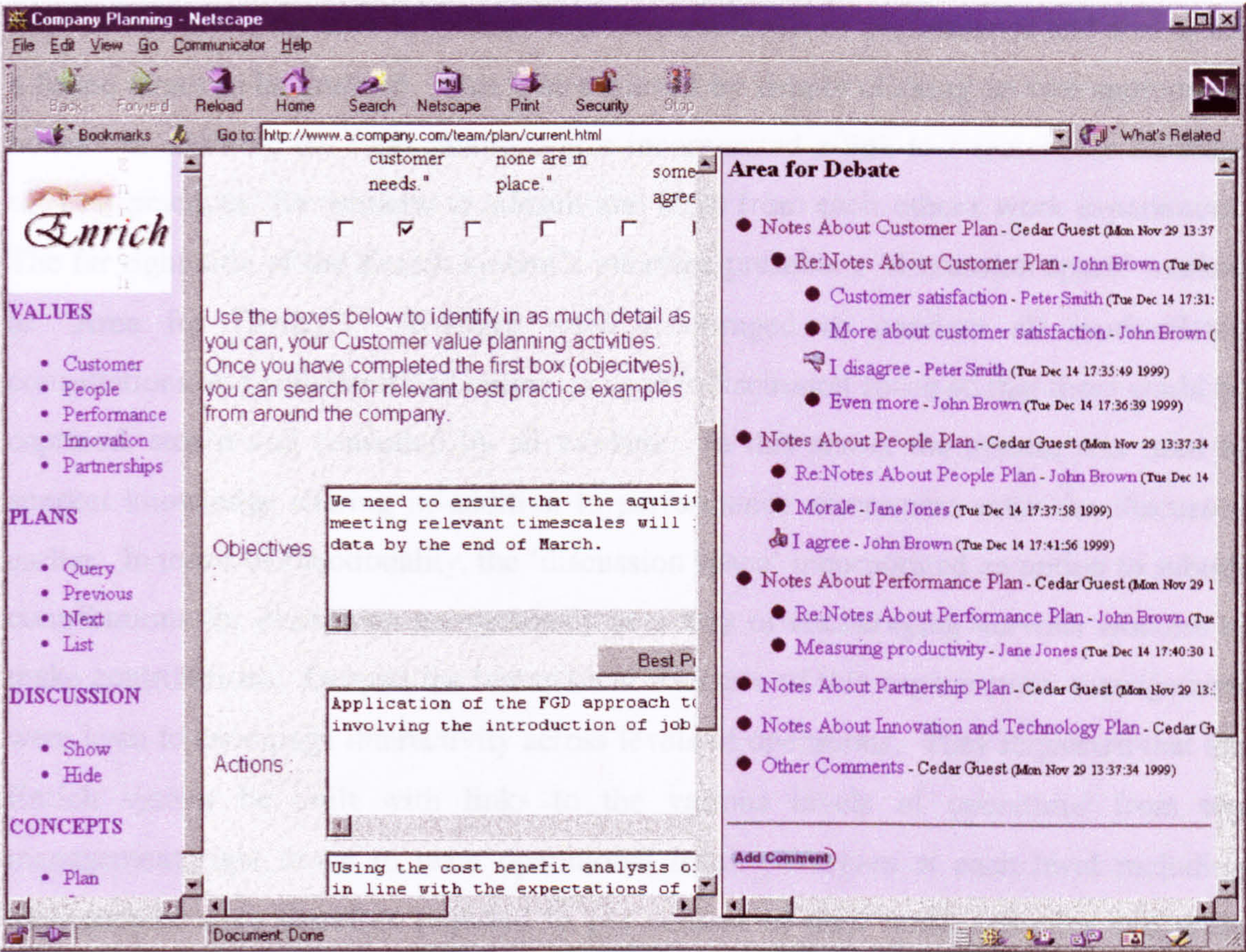


Figure 8: The Enrich System (slightly modified to maintain confidentiality).

The interface and functional features of the Enrich system are described as follows. On the left hand side of the ‘frame-based’ interface is the menu section showing the various options available to the user of the system. These include the five company values as reflected in the paper-based company workbook. The middle part of the system shows an interactive form-based interface that represents the paper-based company workbook’s value-planning sheet. This system-based value-planning sheet was used for setting new objectives to be met, and also to record actions to be performed so as to achieve the outlined objective. Users simply typed into the form interface to set new objectives and record actions to be carried out in order to achieve those objectives. The form also included a computerised version of the value-scoring matrices represented by radio

buttons that allow the user to indicate their current levels of performance and also to set a future target to be attained. This was achieved by simply clicking on two appropriate boxes. In addition, the form interface also incorporated a link to a searchable database of 'best practices' for workers to consult and learn from each other's work experiences. The far right side of the Enrich system's interface presents a 'discussion space' marked as 'Area for Debate'. Workers were encouraged to conduct all work-related consultations and collaborations online using this discussion space so that these could be captured, stored and consulted by all workers. In this sense, the system was used to support knowledge sharing in addition to performance assessment activities discussed earlier. In terms of functionality, the 'discussion space' incorporated an option to submit contributions for discussion anonymously as a way of encouraging nervous workers to make contributions. Despite the hierarchical structure of this organisation, management were keen to encourage interactivity across levels of operations. They requested that the Enrich system be built with links to the various levels of operations from top management right down to team operational level. Workers at each level including management were therefore required to put content of their work activities and plans online so that all employees can universally access them.

Therefore, the design and implementation structure of the Enrich computer system was based on EngiCom's paper-based company workbook and also on information provided by management regarding work practices in this organisation. The Enrich computer system was considered '*enhanced and enriched*' because it provided the additional functions and interactive features that were previously not supported by the paper-based company workbook. The 'enhanced' aspects of the Enrich computer system emerge due to the fact that the system facilitates wider interactivity and increased access to information resources. For example, unlike the paper-based company work, the Enrich system makes it easy to navigate content and find the right information because it incorporates a link to a searchable database of 'best practices'. In addition, this feature enables workers to instantly share knowledge whilst providing increased availability and

access to information. One of the reasons for considering the Enrich computer system to be ‘enriched’ draws from its support for interactive online discussions facilitated by the ‘Area for Debate’ tool incorporated within the Enrich system. The ‘Area for Debate’ tool was designed to enable workers to conduct debate around work issues online using the Enrich computer system. These online discussions were captured and made accessible by all workers as part of the knowledge sharing effort. The paper-based company workbook on the contrary did not provide means for capturing and nurturing work related debate even though similar discussions took place amongst workers in much more unstructured patterns.

The general information gathered about work operations at EngiCom organisation was analysed as follows.

5.3 Data Analysis

The recommended Activity Theory approach to analysing data involves the identification of ‘contradictions’⁴ (Engeström, 1993) in work practices or ‘breakdowns’ (Bødker, 1996) in user-mediator interactions. However, it was difficult to analyse the qualitative data gathered from EngiCom organisation in any critical sense due to the fact that the information gathered was very general in nature. This general information mainly presented management’s overall view of operational processes in this organisation as a whole. Even though the task of gathering general data about EngiCom (section 5.2) was found to be very useful in shaping initial perceptions about the organisation’s work practices, it failed to provide detailed insights about work practices in the various manufacturing sites and levels of operation. For example, it was difficult to analyse the relationships that existed *within* and *between* the various work processes and the levels at which these practices were carried out without having detailed information from people who actually performed these duties. There was therefore, a

⁴ The notion of ‘contradictions’ was discussed in section 3.2.3 under the ‘Activity System’.

need to conduct a detailed and focused investigation of work practices in this organisation. This meant selecting certain manufacturing sites within the organisation so as to conduct a focused study of work practices at team level. A detailed illustration of focused investigations is reported in Chapter 7, which discusses the analysis of team based work practices at EngiCom.

In the meanwhile, the section that follows hereafter will illustrate how the information gathered in section 5.2.1 about EngiCom organisations was used to produce this organisation's activity system as part of the communicative design process of modelling various constitutive elements of the organisation's activity system. In section 5.4, I will describe and show EngiCom's activity system as portrayed in Figure 9. Thereafter in section 5.5, I will outline some of the methodological challenges that emerged during the task of producing EngiCom activity system. Finally in section 5.6, I will present the solution conceptualised to address both the method challenges of modelling activity systems from a situation of investigation, and, also challenges of using the activity triangle model to aid data gathering.

5.4 Communicating acquired insights about EngiCom

Instead of identifying contradictions, the general information gathered as part of this initial study was used to support the design process of interpreting and communicating the acquired insights about work operations at EngiCom. This meant producing EngiCom's activity triangle system to map out the various components and mediators incorporated within that system. The activity triangle system for EngiCom is presented in Figure 9. The figure portrays management's view of work practices in this organisation.

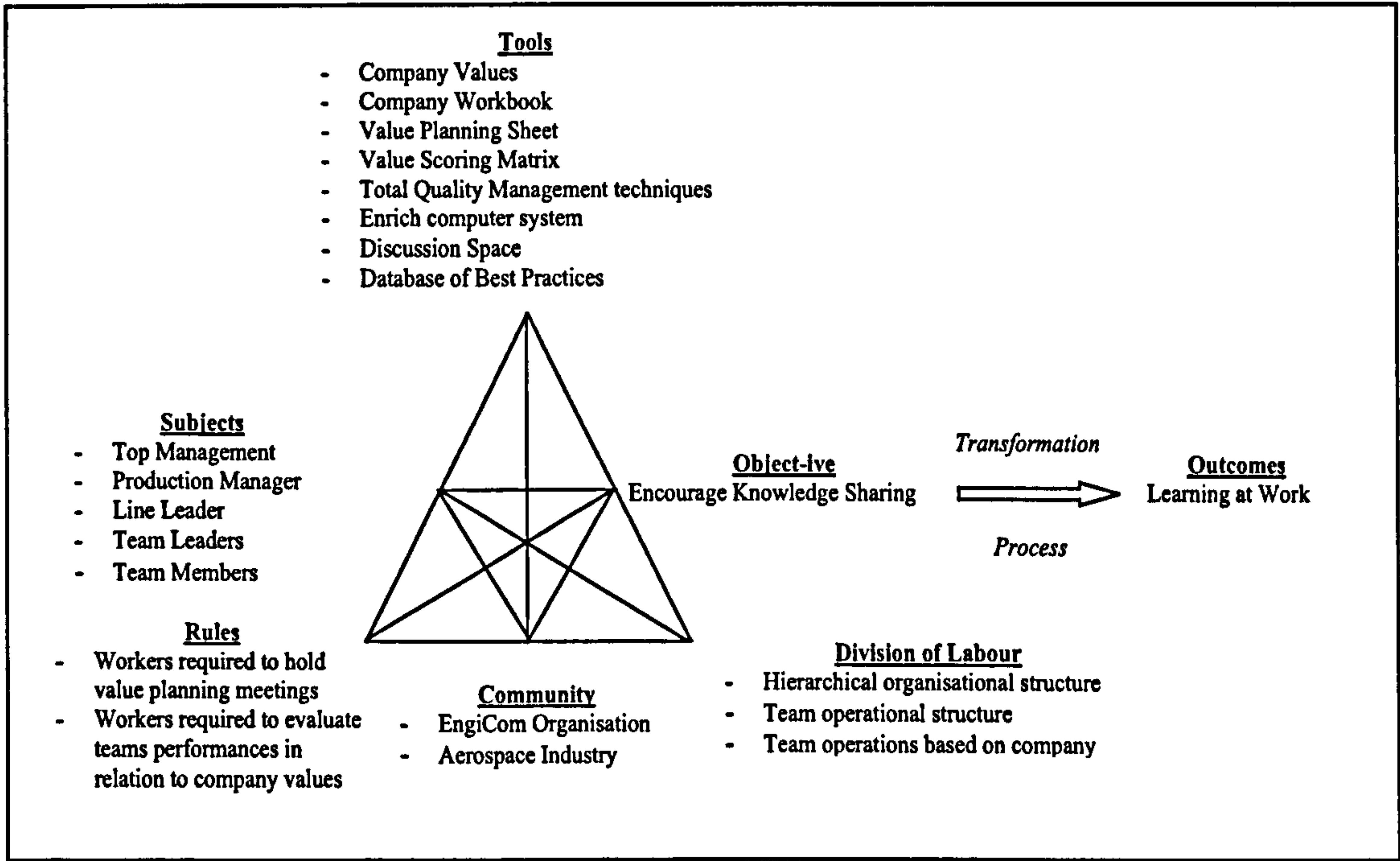


Figure 9: EngiCom Organisation's Activity System (management's view of work practices).

Producing EngiCom's activity system in this way helped to structure the investigation by outlining the various components that are incorporated in the organisation's activity system. Some of the advantages of mapping out an activity system's components include the fact that this approach makes it possible to identify areas to focus on during a detailed study. In addition, the idea of modelling the various components of an activity system can also enable the researcher to establish the availability of resources necessary for a detailed investigation. For example, by mapping out the kind of mediating tools used in an activity, the researcher can assess accessibility to those tools for the purpose of the investigation. Finally, the idea of modelling EngiCom's activity system made it possible to visualise the structure of work activity and support mechanisms (e.g. company workbook) that were in place in this organisation at a more general level.

5.5 Methodological Considerations

From a Method viewpoint, the idea of operationalising Activity Theory by using the activity triangle model to study work practices at EngiCom presented a lot of practical challenges. The task of modelling EngiCom organisation's activity triangle system proved to be complex because there are no guidelines for labelling the various components of the activity triangle model. This created difficulties in determining the significance of the positioning of labels or components of an activity system where they are. It seems the labels have been customarily put in similar positions by several Activity Theory researchers (Engeström, 1978; Kuutti, 1996), whilst the rules governing the labelling of the triangle components, if there are, they do not appear to have been fully explained in the literature. The lack of clear guidelines for labelling components of the activity triangle model has resulted in the emergence of several variations in triangular representations used within the Activity Theory sphere (see for example, Halloran, Rogers, and Scaife (2002)). The significance of this observation to systems design emerges from the fact that variation in approaches to modelling a situation could result in differences in the interpretations of the activity system. Such differences in the interpretations of an activity system can occur even in situations whereby the parties involved in producing the activity triangle systems are actually investigating the same situation. Since the reasons for the fixation of the component labels in the positions, where they are, is rather ambiguous, insufficient explanation of the significance of putting them in those particular positions only increases the ambiguity.

Secondly, whilst attempting to produce an activity system for EngiCom, it was realised that the process of modelling an activity system requires basic understanding or prior knowledge about the situation being examined. In the meanwhile, that prior knowledge is acquired through gathering and analysing data about the situation being investigated. Furthermore, the activity triangle model (Engeström, 1987) in its 'traditional form' does not provide this kind of insight. The realisation of these considerations influenced the

decision to initially restrict use of the activity triangle model to the representational and communicative aspects of design. However, this approach attracted certain criticisms about the feasibility of using Activity Theory to inform early phases of systems design. These criticisms were triggered by the lack of evidence to demonstrate the existence of Activity Theory in the method used to gather data. The main problem here was that, the ethnographic method involving the use of questionnaires and interviews used to gather data at EngiCom had put Activity Theory in the background. Even though it is possible to operationalise Activity Theory principles within ethnographic methods, there still exists a need to demonstrate the mapping between Activity Theory and the ethnographic methods used. The kind of mapping that is required is illustrated in the data interpretation process of producing activity triangles from the information gathered.

Given the foregoing deliberations, it was found difficult to work with the activity triangle model in its 'traditional form' to aid the design processes of gathering and analysing data. Therefore the *Eight-Step-Model* (see Table 6) was developed and used in subsequent studies to help structure the process of operationalising the activity triangle model so as to gather and analyse data from Activity Theory perspective. This approach also helps to obtain basic understanding about the situation of investigation prior to modelling. The Eight-Step-Model achieves this by guiding the interpretation of the various components of the triangle model in terms of the situation being investigated.

The conceptualisation of the Eight-Step-Model was driven by methodological challenges and experiences of examining work practices at EngiCom. Therefore, in order to maintain clarity in both the description of the development and application procedures for the various tools incorporated in AODM, a detailed illustrations of how the Eight-Step-Model was used during empirical investigations will be presented in the next two chapters (six and seven). These two chapters present a systematically comprehensive demonstration and description of how the Eight-Step-Model was used to guide data

gathering and also the communication (modelling) of acquired insights about work practices in the case studies involved. This chapter has already described how information about work practices at EngiCom was gathered (in section 5.2) at a general level through the use of ethnographic type methods involving shadowing, informal social gatherings, document review, and, use of a proxy. In section 5.5, I described my experiences of modelling acquired insights about EngiCom work practices whilst attempting to produce the organisation's activity system which is presented in Figure 9 (section 5.4). These experiences directly influenced the construction of the Eight-Step-Model.

I will now present the various components of the Eight-Step-Model and also describe their methodological functions of this tool. This entails describing how the user can identify for example an “activity of interest” when using the Eight-Step-Model. These illustrations are outlined as follows.

5.6 The ‘Eight-Step-Model’

The Eight-Step-Model		
Identify the: -		Question to Ask
Step 1	Activity of interest	What sort of activity am I interested in?
Step 2	Object-ive	Why is the activity taking place?
Step 3	Subjects	Who is involved in carrying out this activity?
Step 4	Tools	By what means are the subjects performing this activity?
Step 5	Rules and Regulations	Are there any cultural norms, rules or regulations governing the performance of this activity?
Step 6	Division of labour	Who is responsible for what, when carrying out this activity and how are the roles organised?
Step 7	Community	What is the environment in which this activity is carried out?
Step 8	Outcome	What is the desired Outcome from carrying out this activity?

Table 6: The Eight-Step-Model

The *Eight-Step-Model* is a tool within AODM designed and developed to support the process of translating the activity triangle model (see Figure 5 in section 3.2.3) in terms of a situation being examined. It incorporates open-ended questions based on the various components of the activity triangle model. These open-ended questions are

designed to facilitate the interpretation and cross mapping between a situation under investigation, and, the activity triangle representation. The key function of the Eight-Step-Model is therefore to help the researcher to interpret the situation under investigation in terms of Activity Theory by producing an activity triangle system of that situation. Therefore, the idea of producing an activity system helps to communicate acquired insights about the examined situation. In addition to this, the task of interpreting and modelling the various components of an activity system using the Eight-Step-Model also supports data gathering. For example, information about various elements of the situation under investigation is also collected during the process of working through the open-ended questions incorporated in the Eight-Step-Model, therefore acquiring basic understanding about that situation. This basic knowledge is necessary for the purpose of modelling the situation being investigated by producing an activity system of that situation. The Eight-Step-Model therefore simplifies the task of producing an activity system by presenting a systematic illustration of the process of identifying and labelling constitutive components. In addition to this, the Eight-Step-Model helps to focus the investigation by prompting the researcher to identify the '*activity of interest*' from the several activities that may be taking place within a single situation or environment of study. To use the EngiCom case study as an example, it is possible to identify two different activities that could be focused on during the investigation. These are outlined as follows:

- 1) The first activity is the value-planning activity of assessing team performance using the value-scoring matrix.
- 2) The second activity could be identified as that of workers' participating in work related discussions using the 'Area for Debate' tool incorporated in the Enrich system.

The two activities illustrated in the given example are targeted towards two different objectives. The first activity is targeted towards the objective of establishing team efficiency in relation to a particular company value, whilst the second activity is focused on encouraging knowledge sharing amongst workers. The existence of several activities within a single situation motivated by differing objectives signifies the importance of identifying a particular ‘activity of interest’ depending on the purpose or objective for carrying out the study. Given this stance, the ‘activity of interest’ is determined by the researcher’s *objective* for carrying out the study. It is worth pointing out at this stage that the concept of ‘objective’ can be perceived from two perspectives, the *researcher’s objective* and the *subjects’ objective*. Whilst the researcher has an objective for conducting a particular study, the subjects being studied also tend to have a shared objective for engaging in that activity. The expression ‘researcher’s objective’ is therefore used so as to be specific as to which objective is being referred to. The use of these two different expressions of the notion of ‘objective’ will become clear in subsequent empirical illustrations presented in chapter six (see sections 6.1 and also 6.3.1 under ‘Object-ive’).

The Eight-Step-Model helps to identify the ‘activity of interest, by prompting the researcher to answer questions relating to both the ‘activity of interest’ and the ‘Object-ive’ for the existence of that activity. This is accomplished by working through questions presented in Step 1 and 2 of the Eight-Step-Model. The fact that the ‘activity of interest’ is determined by the ‘objective’ for carrying out the study means that Step 1 and 2 of Eight-Step-Model need to be executed sequentially as presented. There is no particular order for working through the remaining Steps of the Eight-Step-Model. The researcher can indiscriminately work through steps 3 to 8 only after working systematically through steps 1 and 2. Finally, the Eight-Step-Model can be applied iteratively during systems design to support the processes of translating the situation of investigation, labelling components of the activity systems, and data gathering. A more

comprehensive illustration of the empirical applications of the Eight-Step-Model in a case study investigation is reported in the next chapter.

5.7 Summary

This chapter initialised the task of explaining how the various method tools incorporated in AODM came to be developed whilst simultaneously demonstrating how these tools can be used to support systems design. During this process, two methodological challenges emerged when analysing work practices at EngiCom using Activity Theory. The first raised questions about how to use Activity Theory to gather data during the study. To address this method challenge, the activity triangle model was used both as a conceptual tool to unify Activity Theory concepts and address key points considered crucial to this thesis (see Table 3 in section 3.1); and also as a practical tool for operationalising Activity Theory concepts for systems design purposes. The second challenge emerged as a result of methodological difficulties experienced in using the activity triangle model in its traditional form. This second challenge was addressed by developing the 'Eight-Step-Model' to operationalise the activity triangle model in terms of the situation being studied. Given these considerations, the development of the 'Eight-Step-Model', offers two methodological achievements outlined as follows.

- 1) The first one is the operationalisation of the activity triangle model. This is demonstrated through the Eight-Step-Model's support for the translation of the various components of the activity triangle model in terms of the situation being examined so as to produce the activity triangle system of that situation.
- 2) The second one is the support for data gathering in terms of Activity Theory. This is demonstrated by using the open-ended questions incorporated in the 'Eight-Step-Model' to aid data gathering. In this sense, the development of the 'Eight-Step-Model' also marked the conception of the technique for 'generating research questions'. However, this technique was not fully

developed until the second case study investigation reported in chapter six (see section 6.5.1.) following further emersions into the AODM development and application.

5.8 Conclusion

This chapter has presented initial practical experiences of operationalising Activity Theory to the study of work practices at EngiCom. In so doing, the activity triangle model was used to unify the various concepts of Activity Theory for systems design purposes. However, practical challenges were experienced in using the activity triangle model to gather and analyse data, also when modelling EngiCom's activity system. These challenges meant that the activity triangle model could not be easily used during the study in its traditional form. The resulting effect was the construction of the 'Eight-Step-Model' as a technique for operationalising the activity triangle representation. The Eight-Step-Model represents one of the method tools incorporated in the Activity Oriented Design Method (AODM) proposed in this thesis.

The next chapter (Chapter Six) will illustrate how the Eight-Step-Model was used to support data gathering and modelling activity systems during an investigation of work practices in the second case study organisation – Comptel.

Chapter Six

6. AODM Development Phase 2 – Comptel Study

This chapter reports on the second phase of the AODM development and application procedure. Within these discussions, details of empirical work carried out using the second organisation - Comptel are presented. The study had two objectives. The first one was to use this case study as a test-bed for evaluating the usability of the *Eight-Step-Model* - developed in phase 1 (Table 6 in section 5.6). This chapter will describe how the Eight-Step-Model was used to study work practices at Comptel. The second objective was to understand work practices at Comptel from a social and cultural perspective using Activity Theory.

Discussions in this chapter are organised as follows. The chapter begins by discussing how the Eight-Step-Model developed in chapter five was used to aid data gathering when studying work practices at Comptel. This is followed by the data analysis section, which describes how data gathered from Comptel was analysed in terms of Activity Theory. Within these discussions, challenging methodological considerations emerged that resulted in the development of additional AODM tools namely, the *Activity Notation*, *Generation of Research Question* and *Mapping of Operational Processes*.

6.1 Data Gathering

In the previous chapter, some of the methodological challenges associated with operationalising Activity Theory using the activity triangle model were outlined. These discussions addressed issues relating to how to use the *activity triangle model* (Figure 5 in section 3.2.3) to support the systems design processes of gathering and analysis data, thereafter, to communicate acquired insights as part of the systems design effort. The

Eight-Step-Model was therefore developed to operationalise the activity triangle model so as to aid these design processes. In order to gather data at Comptel using the Eight-Step-Model, the study began by identifying relevant areas to focus on during the investigation. This meant working through the Eight-Step-Model to identify and isolate a *specific* ‘activity of interest’ from the general work activities that take place at Comptel. The first question outlined in ‘step 1’ of the Eight-Step-Model is the relevant question to ask when trying to identify the ‘activity of interest’¹. The idea of identifying and isolating a particular activity for in-depth analysis helps to focus the investigation on the objective or purpose for conducting the study. The objective of the study therefore determines the kind of ‘activity of interest’ that a researcher identifies for focus. During the study, the *activity of interest* to the researcher was identified as that of obtaining a general understanding of work practices, including mediators that were in place at Comptel organisation. At this stage, the outlined ‘activity of interest’ tend to be vague and general in nature simply because the researcher has not yet acquired basic knowledge about the operations of the organisation being studied. Such basic knowledge can only be obtained through the data gathering process. A more meaningful and specific ‘activity of interest’ is therefore defined in section 6.4 following the data gathering process in which basic knowledge about work practices at Comptel, was acquired.

The next step in the Eight-Step-Model prompts the researcher to define the ‘objective’. In Activity Theory, the objective is supposed to be understood and defined from the subjects’ point of view². This is the subjects’ objective for engaging in activity. However, it was not possible to outline the subjects’ objective at this stage of the study

¹ The idea of identifying the ‘activity of interest’ and also the expressions - researcher’s objective and subjects’ objective has already been discussed in chapter five (see section 5.6).

² Chapter five (section 5.6) discusses the two different perspectives of the notion of ‘objective’, i.e. the *researcher’s objective* and the *subjects’ objective*.

because such information was not yet known. The reason for lack of information about the subjects' objective also draws from the ethnographic principles embedded in Activity Theory. The ethnographic approach emphasises the necessity of understanding practices from the subjects' point of view (Hammersley and Atkinson, 1995). In practical terms, this implies that the researcher ought to begin the study 'with an empty head'. Given these deliberations, the initial *objective* was defined from the researcher's perspective and defined as that of 'understanding work practices and mediators at Comptel'. The subjects' objective is outlined in the 'data interpretation' section by which time the researcher will have acquired basic knowledge about work practices at Comptel through the data gathering process.

The rest of the open-ended questions incorporated in the Eight-Step-Model were used to gather information relating to the various components of the activity triangle model from Comptel. The open-ended questions were used during unstructured interviews, observational studies and document reviews. Unstructured interviews were conducted in the workers' normal work environment at Comptel. The interviews were structured as informal or semi-formal discussions with selected individuals or groups of workers. During these sessions, open-ended questions from the Eight-Step-Model served as 'reminders' as to the kind of questions to ask and as pointers to the kinds of issues to explore during the enquiry. In observational studies, open-ended questions from the Eight-Step-Model were used to direct the researcher to issues to pay attention to when watching workers carrying out their duties. Due to security reasons and restrictions resulting from company regulations, taking photographs, video or audio recording of data collected was not allowed. I therefore took notes (handwritten) to keep a record of data gathered during interviews and observational studies. Another data gathering method employed when studying work practices at Comptel involved the review of company documentation. The kind of documents reviewed included paper-based and system-based work manuals, internal and external reports. Also evaluated were

company publicity materials already in the public domain, for example Comptel product promotional magazines and Comptel financial reports. These were available in public libraries. When reviewing company documentation, open-ended questions were also used to direct or point the researcher to the kind of information to look for. In addition, further information about work practices at Comptel was gathered through social interactions with workers, for example, in staff canteens during lunch breaks. The researcher maintained a research journal, which was used to record data gathered through document reviews and social interactions. Finally, a compact disc (CD) containing information about Comptel's products, online manuals, customer support structure, was also made available. The qualitative information gathered about Comptel work practices is illustrated in the next section.

6.2 About Comptel

Comptel operates in the industrial computing sector and they are based in Germany. They develop and maintain software for industrial computing systems for their customers all over the world. Part of this maintenance involves rendering continuous customer support on products sold. The organisation was trying to provide better customer support by encouraging workers to share their knowledge and experiences about resolving customer problems. Management in this organisation had recognised the important role that a computer could play in managing and co-ordinating knowledge sharing activities. Within the framework of the Enrich project, Comptel management commissioned the development of a computer system to support knowledge sharing activities in the organisation. The rationale behind the introduction of this computer system was influenced by management's desire to make work practices explicit. They had hoped that this would encourage workers to share and re-use knowledge about solving customers' problems with products bought from Comptel. Therefore, a bespoke version of the Enrich system was to be built for Comptel. At the time of this study, the Enrich system for Comptel had not yet been implemented.

The next section will give a detailed description of Comptel's operational structure. These discussions will mainly focusing on outlining the structure and work procedures of Comptel's 'Customer Support Unit'.

6.2.1 Comptel's Operational Structure - CSU

Comptel's commitment to offering customers support on products sold meant that this company had a dedicated Customer Support Unit (CSU) responsible for rendering 'after-sales' support for the various products sold to customers. The CSU is made up of three sections (see Table 7) responsible for supporting both internal and external customers of the organisation. Internal customers were employees or other units within Comptel, whilst external customers refer to outside organisations that buy products from Comptel Systems. The CSU is organised in a hierarchical structure involving three support sections operating at three different levels namely; 'Despatch Centre', 'Online Support', and, 'Complicated Reports'. Table 7 shows in a hierarchy, the three support sections of Comptel's CSU, whilst indicating the level at which each section operates.

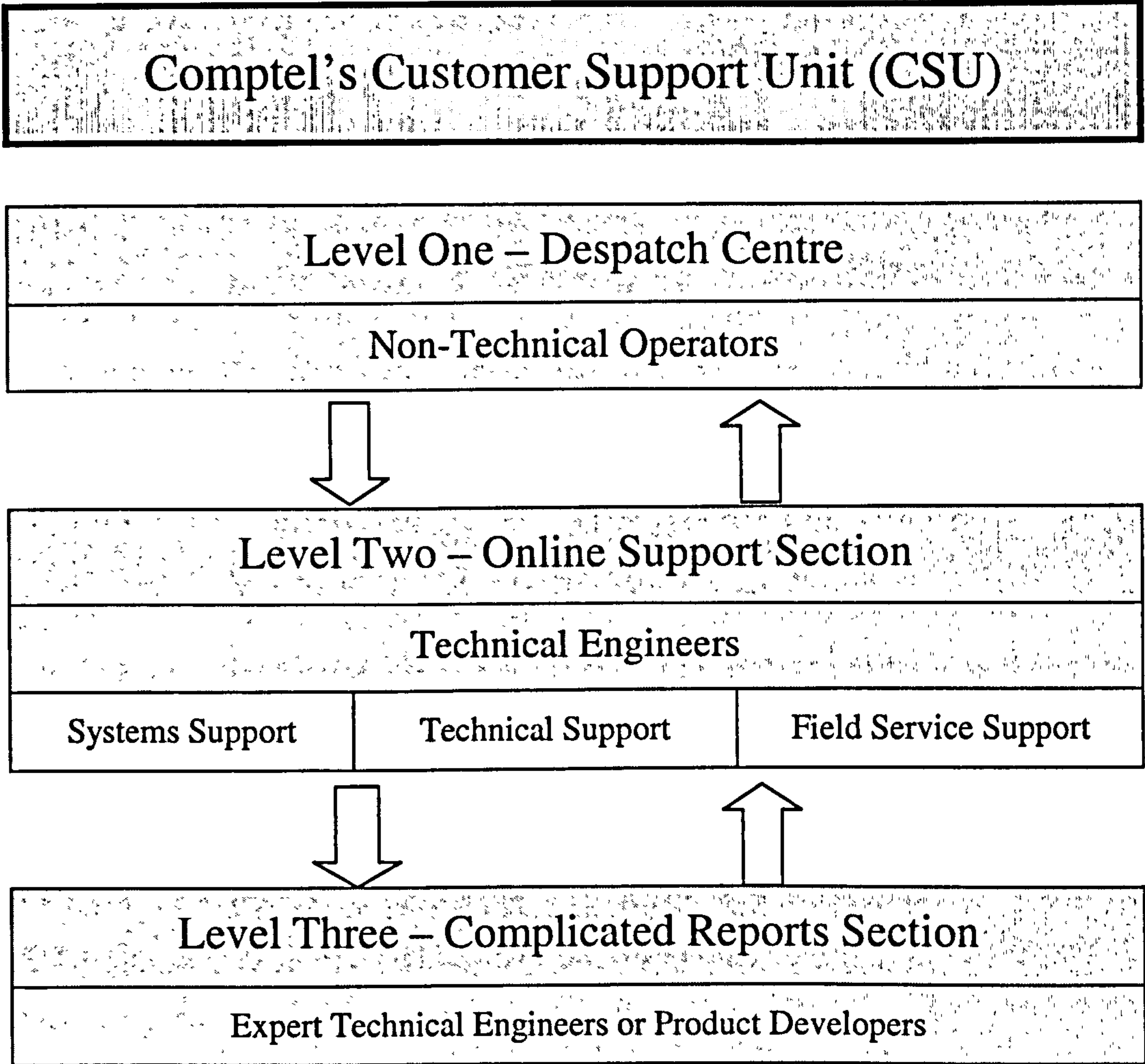


Table 7: Operational Structure of Comptel's CSU

Level One - Despatch Centre

Operating at Level One, the ‘Despatch Centre’ is the first point of contact for customers of Comptel experiencing problems with products bought. The ‘Despatch Centre’ consists of a single large team of non-technical operators who man it. In terms of education ‘Despatch Centre’ operators had basic education of up to secondary school or GCSE ‘O’ level equivalent. English and German were the main business languages used to communicate with customers. ‘Despatch Centre’ operators were therefore encouraged to improve their communication skills in these languages especially English.

Their main duties were to handle general inquiries about products, also to record reported problems about products. Customers used various mechanisms to report problems experienced with products bought from Comptel. Problem reporting mechanisms included the use of telephone, email and fax. 'Despatch Centre' operators were given on-the-job-training on how to handle inquiries and problem reports from customers using telephone and email systems. From this perspective, the main responsibility of 'Despatch Centre' operators was to obtain the right information about the problem being experienced by a customer, thereafter to create a problem case. This involved gathering as much information as possible about the product and problem description from the customer. The information gathered about the problem included contact details of the customer reporting the problem. This information was entered in a database of 'problem cases', a term used to refer to records of customer problems. The organisation also used a Case Based Reasoning (CBR) system to support the tasks of searching and matching problem cases available in the database. The CBR was integrated with another computer-based tool known as the Call Tracking System (CTS). The CTS was used to trace and monitor progress on solving customer problems. Using the CTS, progress on solving a customer problem could be traced from the first time a problem case is received from a customer, right up to the time the problem gets resolved. The CTS incorporated features for identifying the person dealing with the problem case, the status of the case, and also the predicted duration for resolving the case. The database of products' problem cases was accessible by all CSU workers regardless of the level at which they are operating. This way, all workers in the CSU can view the cases that have been entered together with details of individuals and the support section dealing with those cases. Despatch Centre operators were given training on how to enter problem cases into the database and also how to check the progress of solving a customer problem using CTS. Once product problem cases have been created and entered into the database, Despatch Centre operators allocated them to teams of workers operating at Level Two of the CSU - the Online Support Section.

Level Two – Online Support Section

The Online Support section initiates the process of solving customer problems by taking up cases referred to them by the Despatch Centre. Online Support workers also get cases to work on from the database system. Operating in the Online Support section were technical engineers with a good understanding of the technical aspects of the product design and application. Technical engineers working in the Online Support sections were organised in three specialist support areas namely, systems support, service support and field service support. The three specialist support areas are discussed as follows.

Systems Support

The systems support unit consisted of several teams of about 8 to 10 engineers in each team. Workers operating in systems support had good general technical knowledge of the design and application of various Comptel products. In addition to that, these engineers also had a good understanding of the customer's business operations and support mechanisms for the customer's existing systems. Systems support workers were responsible for helping customers who buy new products to integrate the new system with the customers' already existing systems.

Technical Support

The technical support unit mainly consisted of a single team of engineers or product developers (programmers) who had in-depth knowledge of how a product was developed and also how it works. Engineers working in this area offered technical support to both internal and external customers of the organisation.

Field Service Support

The field service support unit consisted of a single team of technical engineers whose main responsibility was to provide local support to subsidiaries of Comptel that are based at other divisions. The kind of support offered included the provision of spare parts for products. In addition to this, field service support engineers also provided support to external customers of Comptel at their premises. Field service engineers usually liaised with product developers in the technical support unit when solving cases, whilst in the field.

Online Support Section's procedure for solving a problem case

The main duties of workers in the Online Support section were to provide general online support to external customers of Comptel. In so doing, they used various tools as resources to facilitate the process of resolving customer problems. These tools included paper-based and computer based manuals. Online Support workers were also encouraged to participate and refer to online discussions on Comptel's web discussion forum. The discussion forum was accessed both through the company Intranet and the Internet. Confidential information was only accessible via the Intranet. The organisation employed two product support systems for solving cases. These included a fast track system and a basic rate system. Cases considered under the fast track system were pre-paid for and charged at a high rate. Cases dealt with under the basic rate system were not pre-paid for, in addition, they were charged at a low rate. Since fast track cases were prepaid for, a '3 hour rule' was introduced to set the maximum time for dealing with problems in this category. This meant that fast track cases took priority over basic rate cases. There was no fixed time for solving basic rate cases.

Despatch Centre operators usually referred problems cases to workers and teams in the various units of the Online Support section. In turn, problem cases were sometimes referred from one unit to another within the Online Support sections depending on the

type of problem and specialist knowledge required to solve the problem. For example, engineers working in systems support could refer a case to technical support if it was felt that developer expertise was required. At the same time, in situations where field service engineers were unable to solve a problem whilst in the field, technical engineers would be consulted or the case would be referred to them. Difficult cases that could not be solved quickly by Online Support engineers operating at Level Two were considered to be complicated cases. These complicated cases were passed down to the 'Complicated Reports' section operating at Level three so that a thorough investigation could be conducted.

Level Three –Complicated Reports section

The Complicated Reports section is made up of a single team of experts or highly qualified technical engineers with specialist skills in product development and applications. These engineers mainly deal with difficult or complicated cases that cannot be resolved by specialist teams in the Online Support section at Level Two. To resolve a complicated case, engineers in the Complicated Reports section normally began by obtaining as much information as possible about the problem from the person at Level Two who referred the problem. The person at Level Two who refers a case to Level Three was known as the 'problem author'. Once adequate information about the problem had been obtained from the problem author, the expert engineer working in the Complicated Reports section attempts to simulate the problem. In simulating the problem, the expert engineer tries to apply suitable solutions as part of the investigation. Should further investigations be required, manuals, online materials and other experts within the CSU were consulted, for example, product developers. In the meanwhile, the customer was always kept informed about the actions being taken to solve the problem. Once the problem was resolved, the solution was given directly to the customer. The problem author in the Online Support section (Level Two) was also informed. Cases dealt by the Complicated Reports section usually took a long time to solve. During this

time, customers were only allowed to contact Complicated Reports engineers when making a follow-up on the case. Making a follow-up on a case was only allowed in situations whereby a customer had been informed that the Complicated Reports section was dealing with their problem and also where the name of the engineer working on the case was known.

Table 8 presents a problem solving scenario at Comptel's CSU.

Example of a Problem Solving Scenario at Comptel

- A customer contacts the Despatch Centre using a telephone, email, or fax to report a problem with a product bought from Comptel.
- A Despatch Centre operator gathers detailed information about the problem including the customer’s contact details. The operator then creates a problem case in the database. Thereafter, the operator allocates the case to one of the systems support teams operating in the Online Support section at Level Two.
- An engineer in the relevant ‘systems support’ team then checks whether the customer has prepaid for the case or not. This information is used to determine the category of the case i.e. ‘fast track’ or ‘basic rate’.
- Thereafter, the systems support engineer attempts to solve the problem case by consulting paper based and online manuals.
- If the problem can be solved immediately, the engineer gives the solution directly to the customer.
- If the problem requires specialist skills to solve, then the engineer transfers the case to the right specialist team within the Online Support section.
- On the other hand, if the problem is considered to be complicated, the engineer refers it to the Complicated Reports section and advises the customer accordingly.
- An expert engineer in the Complicated Reports section then takes the case. The engineer gathers as much information as possible from both the problem author at Level Two and the customer if necessary. Thereafter, the expert engineer simulates the problem on their systems and applies possible solutions to try and solve the problem. Once resolved, the solution is given directly to the customer, whilst the problem author at Level Two is advised accordingly. Finally, the problem case is closed. Both the problem details and solution are entered into the database for future reference.

Table 8: Problem solving scenario at Comptel

6.2.2 Knowledge Sharing practices within Comptel's CSU

Workers in all sections of the CSU were required to identify and gather suitable problems and solutions from their workloads whilst carrying out normal duties so that a database of Frequently Asked Questions (FAQs) and solutions could be created. This database was to be accessed and consulted by all workers in the CSU, as well as external customers via the Intranet. In the meantime, management in this organisation had also introduced the use of a performance rating system so as to monitor both individual and team performances. The rationale behind the introduction of this performance rating system was to encourage competitiveness amongst teams and workers in general. Bar charts were used as performance indicators. These bar charts showed the total number of problem cases received, the number of cases resolved, the number of cases pending, also the number of cases targeted. Bar charts also indicate whether cases were 'fast track' or 'basic rate' categories.

Each team normally supported a single product at any given time so as to allow specialisation. The organisation operated a job rotation system in order to allow workers to familiarise themselves with duties carried out by other workers in teams that were supporting different products. Team workers had a work cultural norm of consulting a 'local unofficial expert' amongst themselves when faced with a difficult case. The local unofficial expert was someone recognised by fellow workers to be someone knowledgeable about a particular product. In addition, a local unofficial expert was someone willing to assist other workers once consulted about a problem regarding a product.

6.3 Data Analysis

In order to make sense of work practices at Comptel, there was a need to analyse qualitative data gathered in terms of Activity Theory's *notion of contradictions*. This

involved the identification of problems or breakdowns *within* and *between* work practices (Kuutti (1996, Engeström, 1999). However, in order to identify contradictions that are meaningful to the Comptel work context, it is important to interpret, communicate and verify the correctness of the data gathered with workers who perform the analysed practices. The significance of verifying the correctness of data gathered emerge from the fact that a correct interpretation of data gathered is likely to result in the identification and communication of meaningful contradictions. Incorrectly interpreted data on the other hand could yield less meaningful contradictions. Given this consideration, the process of analysing data gathered from Comptel was commenced by verifying the correctness of the information gathered about work practices in this organisation prior to identifying contradictions. This involved the production of Comptel's activity triangle system as a mechanism for communicating (discussed in detail in section 6.4) acquired insights about the organisation's work practices. One of the key advantages of modelling an organisation's activity system draws from the fact that it helps to summarise and structure information, therefore, making it easier to understand the interpretation of work practices. Therefore, this approach can enable the researcher to obtain coherent feedback about work practices studied. Detailed discussions about Comptel's work practices are illustrated as follows.

6.4 Communicating acquired insights about Comptel

The process of interpreting data gathered about work practices at Comptel involved working through the 'Eight-Step-Model', this time to identify the 'subjects', 'tools', 'rules', 'community', 'division of labour', 'object-ive' and 'outcome' components of the activity triangle model (Figure 5 in section 3.2.3). This interpretation process involved answering open-ended questions incorporated in the 'Eight-Step-Model' in relation to data gathered about work practices at Comptel. This information is outlined as follows:

Activity

The *activity of interest* to the researcher was identified as that of understanding *knowledge sharing practices amongst workers* at Comptel's CSU.

It is worth explaining at this point that the 'activity of interest' identified during the data interpretation stage can differ from the 'activity of interest' initially outlined in the data gathering section 6.1. The main reason for this discrepancy is that, once data has been gathered the investigator will have obtained enough basic knowledge about the kind of activities that take place in the situation being studied. The existence of basic knowledge makes it possible to be specific when defining an 'activity of interest' during data interpretation. This kind of insight is not available when working through the Eight-Step-Model at data gathering stage. In addition, the reader may notice that the identified 'activity of interest' may appear to be similar to the outlined 'objective', again this is in line with Leont'ev's definition of an activity which states that an *activity* is identified by its *objective* (Leont'ev, 1981; 1978). This is also discussed in chapter three (section 3.2.2) of this thesis.

Object-ive

From Comptel's point of view, the main *objective* of this activity was to *encourage knowledge sharing* amongst workers.

As discussed previously in the data gathering section (6.1) an *objective* can be defined from both the investigator's or the subject's viewpoint. This is so because whilst the investigator has an objective or motive for studying particular work practices, the people (subjects) involved in carrying out those practices also tend to have an objective for engaging in the activity being studied. The objective of the investigator and that of the subject are not the same. Given that Activity Theory emphasises the need to understand

work practices from the subjects' point of view, the objective identified in this data interpretation is outlined from Comptel's point of view.

Outcome

The *desired outcome* from Comptel workers' knowledge sharing activity was to provide better customer support.

Subjects

Subjects involved in this activity were identified as single individuals working on their own or in collaboration with other individuals within Comptel's CSU. Subjects also included groups of individuals working together in a team and finally, a team working in collaboration with another team to provide customer support on a product bought from Comptel.

Mediators (Tools, Rules, Division of Labour)

The organisation already had in place several mediators³ to support the activity of sharing knowledge about solving customer problems. These *mediators* are listed as follows:

- 1) A computerised Call Tracking System (CTS) (*Tool*) used to trace and monitor the progress of a problem case.
- 2) Online and paper based manuals (*Tools*) used as information resources for workers to refer to when resolving cases.

³ The term 'mediator' defined and discussed in detail in section 3.3.2, under 'tool mediation'. See also section 3.2.1. Briefly it refers to the introduction of a medium or a third party as a facilitator in between two entities, for example, a pen can be seen as a mediator in the activity of writing a letter. Therefore, we can have the person (subject as entity number one), and then a pen or paper (as mediator), then a letter (object-ive as entity number two).

- 3) The two different product support systems (*Division of Labour*) employed by workers when solving cases.
- 4) A '3 hour rule' (*Rules*) introduced for dealing with fast track cases.
- 5) A database (*Tool*) of frequently asked questions (FAQs) with answers developed to encourage workers to share their experiences of solving cases.
- 6) The proposed 'Enrich system' for Comptel.
- 7) Use of a performance rating system (*Rules*) to monitor both individual and team performances.
- 8) Use of bar charts (*Tool*) as performance measures.
- 9) The introduction of a specialist product team support structure whereby each team normally specialised in supporting a single product (*Division of Labour*).
- 10) The operation of a job rotation system (*Division of Labour*).
- 11) Finally, the work *cultural norm* of consulting a local unofficial expert within the team when faced with a difficult case (*Rules*).

The above information was used to produce Comptel's activity system as shown in Figure 10.

Comptel’s Activity System

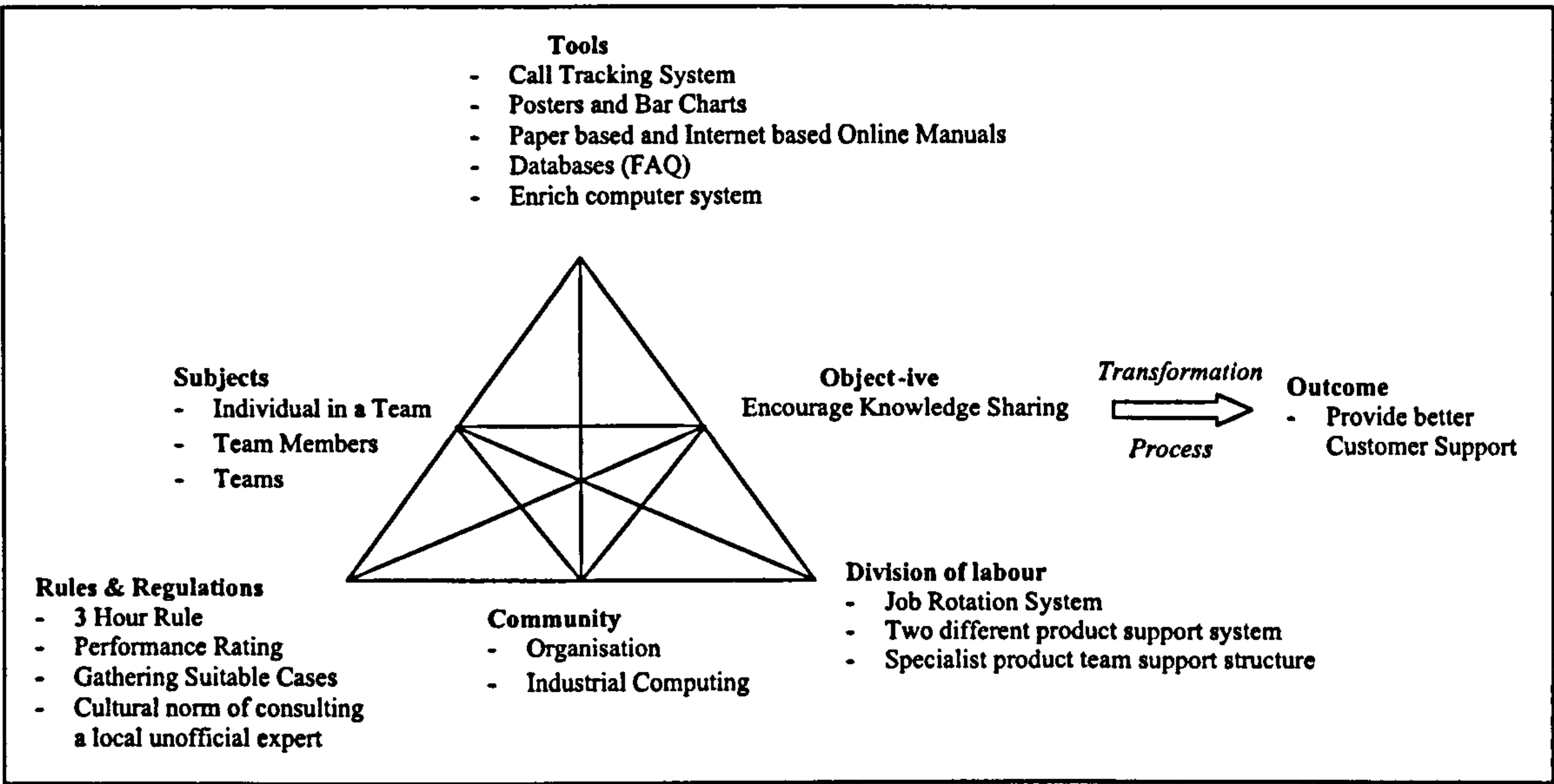


Figure 10: Comptel’s activity system

Identifying contradictions in Comptel’s work practices

Following the interpretation of data gathered from Comptel, the next task was to identify contradictions or problems in Comptel’s work practices. Engeström (1993; 1999) particularly emphasises the importance of contradictions⁴ in understanding work practices. He argues that contradictions help to identify problematic areas whose investigation is necessary for the purpose of understanding what is happening in an activity system. According to Kuutti (1996, p.34), contradictions come to light through ‘misfits,’ problems or breakdowns *within* or *between* elements of a single activity system. In practice, Kuutti’s (1996, p.34) definition of contradictions implies that Activity Theory based data analysis ought to focus on understanding the relationships

⁴ The notion of contradictions was defined in section 3.2.3 under the ‘Activity System’.

that exists *within* and *between* the various components of a single activity system. However, it was methodologically not possible at this stage to use the AODM in its current state to identify relationships and problems that may exist *within* and *between* the various elements of Comptel's activity system outlined in Figure 10. As a result, the author found it necessary to discuss methodological considerations that emerged before presenting identified contradictions in Comptel's work practices. An outline of contradictions identified in Comptel's work practices is presented in section 6.9. In the meanwhile, discussions relating to methodological considerations are presented as follows.

6.5 Methodological Considerations – Part A

Use of the Eight-Step-Model (see Table 6 in section 5.6) in this case study helped to interpret and communicate acquired insights about work practices at Comptel in terms of Activity Theory by producing the organisation's activity system. However, the organisation's activity system that was produced was found to be very complex because it incorporated various components or sub-activities that together make up Comptel's main activity system. This complexity made it impossible to conduct a critical analysis of Comptel's work practices. For example, an initial attempt to analyse Comptel's activity system presented in Figure 10 did not provide a clear indication of the inter-relatedness of the various components of the system. The Eight-Step-Model does not capture detailed information about the inter-relatedness of activity triangle components. These observations indicates a limitations in the Eight-Step-Model's support for gathering detailed data from the context of study. In order for the study to be able to draw meaningful conclusions from the analysis of work practices at Comptel, there was a need to understand the internal relations that exist *within* and *between* the various components or elements of Comptel's activity system. At the same time, it was also important to establish how and why these relations occurred. As a result of these methodological considerations, the *Activity Notation* was developed to support the

decomposition of Comptel’s complex activity system into smaller manageable units or sub-activities that together makes the Comptel’s main activity system.

6.5.1 Development of the Activity Notation

The *Activity Notation* (see Table 9) was developed as an additional Method tool to be incorporated in the AODM.

Actors (Doers)	~	Mediator	~	Object-ive (Purpose)
Subjects	~	Tools	~	Object
Subjects	~	Rules	~	Object
Subjects	~	Division of Labour	~	Object
Community	~	Tools	~	Object
Community	~	Rules	~	Object
Community	~	Division of Labour	~	Object

Table 9: Activity Notation

The main operational function of the Activity Notation is to aid the process of breaking down a complex activity triangle system into sub-activities so as to reduce complexity. The approach to breaking down an activity system does not imply that the generated sub-activities can be studied independently or as representative units of the main activity system. Instead, when analysing data, the relationship *within* and *between* the various sub-activities are to be understood in relation to the objective of the main activity system being examined. This decomposition technique was introduced to solve and handle the

complexity of the main activity system. For this reason, the generated sub-activities are constitutive elements of the main activity system and are united together through the object-ive of the main activity system.

Three-operational-guidelines (shown in Table 10) were then conceptualised so as to explicate the operational structure of the Activity Notation when decomposing an activity system to support levelled abstraction. The *three-operational-guidelines* stipulates that each combination within the Activity Notation shall:

Three-Operational-Guidelines (for the Activity Notation)
1) Be focused on the <i>Object-ive</i> of activity.
2) Consist of an <i>Actor</i> or a <i>Doer</i> of activity represented by a <i>Subject</i> or a <i>Community</i> component.
3) Consist of a <i>Mediator</i> of activity represented by the <i>Tool</i> , <i>Rules</i> or <i>Division of Labour</i> component.

Table 10: Shows the three-operational-guidelines (for the Activity Notation)

Each combination within the Activity Notation represents a complete sub-activity triangle from the main activity system; for example, it is possible to identify the *Subject-Rules-Object* sub-activity triangle from Comptel’s activity system presented in Figure 10. The primary purpose of the Activity Notation is therefore to structure data analysis when investigating work practices. For example, it is also possible to recognise that the mediated relationship *within* the Subject-Rules-Object sub-activity triangle of Comptel’s

activity system (Figure 10) could be analysed in terms of the application of rules that exist in that context.

6.6 Methodological Considerations – Part B

Even though the introduction of the decomposition technique through use of the ‘Activity Notation’ helped to reduce the complexity of Comptel’s activity system by making components explicit, and also structuring the analytical process; this decomposition does not provide guidance on how to analyse the inter-relatedness of the various sub-activities of an activity system. In order to address this issue, a technique for *generating research questions* based on the various combinations of the ‘Activity Notation’ was developed.

6.6.1 Development of the technique of Generating Research Questions

An approach to generating research questions based on the various sub-activity triangles or sub-activities of the main activity system was developed. The kind of research questions generated using this approach can either be general or specific. General research questions are generated from a decomposition of an untranslated activity triangle model, for example the activity triangle model shown in Figure 5 of chapter three. Such a representation only shows traditional labels of the activity system’s components. Examples of general questions that could be generated based on the described approach are presented as follows.

The six general research questions

- What **Tools** do the **Subjects** use to achieve their **Objective** and how?
- What **Rules** affect the way the **Subjects** achieve the **Objective** and how?
- How does the **Division of Labour** influence the way the **Subjects** satisfy their **Objective**?
- How do the **Tools** in use affect the way the **Community** achieves the **Objective**?
- What **Rules** affect the way the **Community** satisfies their **Objective** and how?
- How does the **Division of Labour** affect the way the **Community** achieves the **Objective**?

Table 11: Examples of General Research Questions

The questions generated using this approach are driven by the representation presented in the notational combinations outlined in the ‘Activity Notation’ (Table 9). This means that a sub-activity triangle can be identified in each generated question. For example, it is possible to recognise that the first question in Table 11 is addressing the ‘**Subjects-Tools-Object**’ sub-activity triangle as portrayed in Figure 11. The represented sub-activity triangle is highlighted using orange borders.

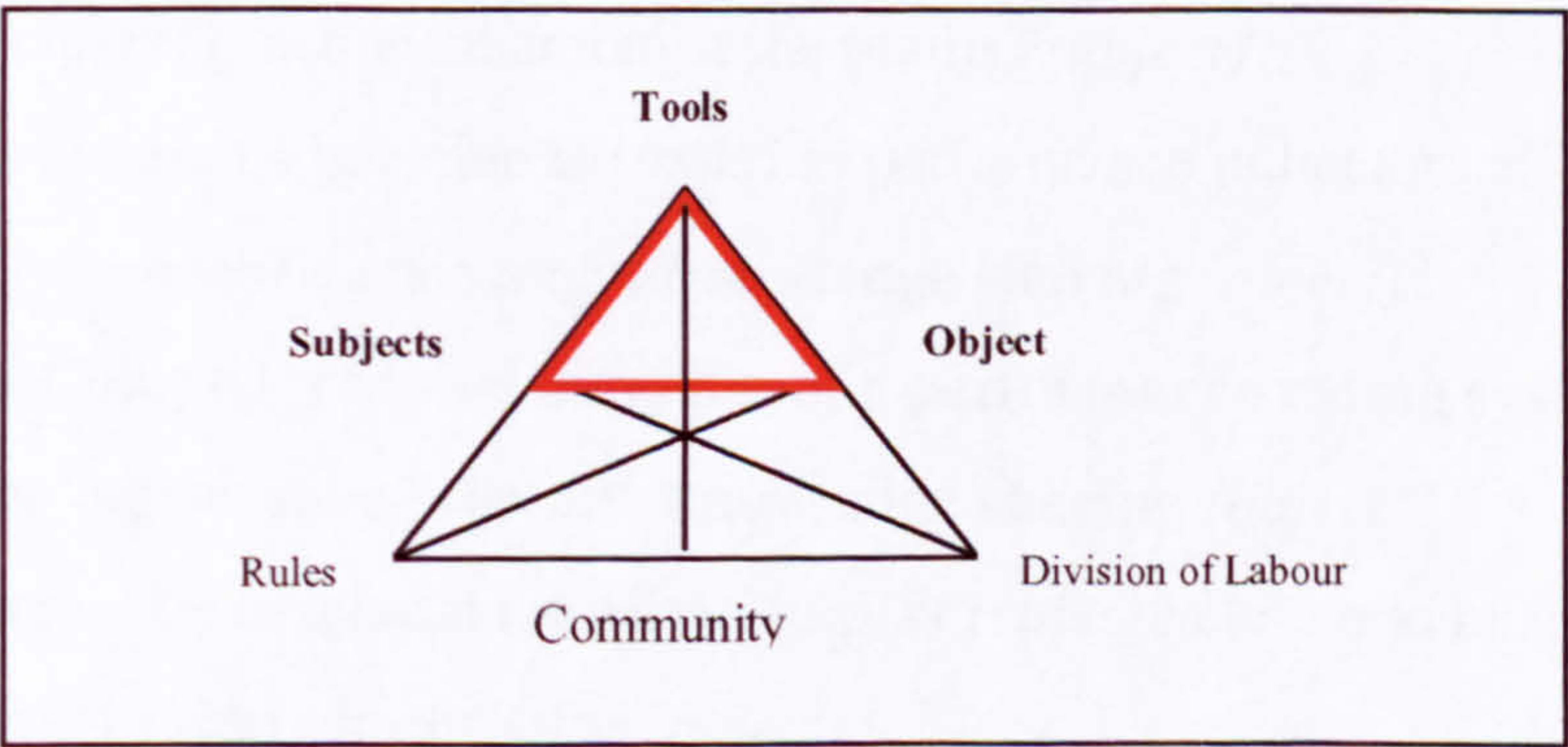


Figure 11: Shows focus on the Subject-Tools-object sub-activity triangle

Specific research questions are generated from a decomposition of a translated activity triangle model, for example, Comptel’s activity system shown in Figure 10 (this chapter). In this case, labels of the traditional activity triangle model are only shown as headings of the various components. For example, under the ‘tools’ sub-heading, it is possible to see that some of the ‘tools’ used at Comptel included the ‘Call Tracking System’, ‘Bar Charts’ etc.

Table 12 shows examples of some of the specific research questions generated for use during the analysis of work practices at Comptel.

Examples of specific research questions - Comptel
<ul style="list-style-type: none">- How does the call tracking system (<i>tools</i>) support knowledge sharing (<i>object</i>) amongst teams (<i>subject</i>)?- How does the <i>rule</i> of identifying and gathering suitable FAQs from cases whilst working affects knowledge sharing (<i>object</i>) amongst individuals and teams (<i>subject</i>)?- How does the job rotation system (<i>division of labour</i>) affect the way knowledge sharing (<i>object</i>) is achieved amongst the teams (<i>subject</i>)?- How does the use of bar charts (<i>tools</i>) as performance indicators affect the way Comptel (<i>community</i>) encourages knowledge sharing (<i>object</i>)?- How does Comptel 's (<i>community</i>) use of a performance rating system influence the way the organisation promotes knowledge sharing (<i>object</i>)?- How does the use of a local unofficial expert (<i>rules</i>) help workers at Comptel (<i>community</i>) to share knowledge (<i>object</i>)?

Table 12: Comptel Specific Research Questions

Research questions generated either in general or specific forms are relevant to a particular notational combination within the Activity Notation. They represent a sub-activity triangle either in the general (traditional) activity system or Comptel activity system. The generated research questions could be used to aid the design processes of gathering and analysing focused data about relationships *within* and *between* sub-activities of an activity system. To aid the data gathering process, generated research questions could be used during observational studies, in questionnaires and interviews. During data analysis, generated research questions could be used to help the researcher identify necessary relationships and problems that may exist *within* and *between* sub-activities of an activity system.

After working through the outlined methodological considerations and following the development of the various AODM tools (*Activity Notation* and the *Generation of Research Questions*), data gathered from Comptel was revisited and analysed as follows.

6.7 Analysis of work practices at Comptel

The specific questions generated about Comptel work practices were used to analyse relationships *within* and *between* sub-activities in the Comptel activity system so to identify contradictions. These specific questions made it possible to obtain meaningful data concerning work practices at Comptel. In order to effectively carry out this analysis, two key relationships were identified as being crucial for understanding work practices in this organisation. These are outlined as follows:

1. The relationship *between* workers in a team (*Subjects*) and the objective (*Object*) of knowledge sharing.
2. The relationship *between* Comptel's (*Community*) management practices and the objective (*Object*) of encouraging knowledge sharing amongst workers.

The two relationships outlined were chosen because they can help to establish the kind of tensions that can exist *between* management and teams whilst focusing on the shared objective for the activity under investigation.

These two relationships were analysed by focusing on the role of mediators (*Tools, Rules and Division of Labour*) *within* and *between* each sub-activity of the Comptel activity system. When analysing Comptel work practices, as well as trying to establish how knowledge sharing was mediated in a work context, the analysis also investigated how knowledge sharing processes were hindered through the use of mediators and also other forces in the organisation. For example, by asking the question relating to Comptel's regulation of using a performance rating system, it is possible to identify two areas of contradiction. The first results from the *use of 'bar charts'* whilst the second emerges as a result of the team's work cultural norm of seeking help from a '*local unofficial expert*' (see for example, Appendix A-20 on page 275, also Appendix A-15 on page 258).

The organisation's monitoring of both individuals and team performance through the use of weekly bar charts created a competitive work culture. In this culture, workers were concentrating more on improving their own performance ratings, which meant resolving as many cases as possible. Therefore, workers saw the organisation's requirement to identify and gather FAQs for the database as a 'side-track' that would slow down the activity of resolving many cases in order to improve performance ratings on the bar chart (see for example, Appendix A – 20, on page 275). This situation created internal contradictions *within* the 'Rules' making sub-activity system as it was difficult to find a suitable compromise between working efficiently to improve personal ratings and finding time to reflect on work performances in order to gather suitable FAQs for the database.

Further contradictions were identified *between* the ‘division of labour’ and ‘subjects’ sub-activity systems as a result of the organisation’s operation of a job rotation system (see field notes in Appendix A – 15, on page 258). The job rotation system required workers to move around to other teams that were supporting completely different products. Different teams had different team work cultures. The job rotation system was introduced under the auspices of familiarising workers with other duties as a way of sharing knowledge that presumably would lead to better customer support. Even though the job rotation system had advantages of familiarising workers with work practices of other teams working on different products, the analysis showed that this job rotation disturbed the team social and work culture through the frequent re-organisation and re-allocation of responsibilities. Teams were forced to accommodate people who joined or left the team. In situations where the unofficial local expert was suddenly moved to another team, the system introduced problems for them to ‘fit in’ with the new team. Even if the unofficial expert did fit in, there was no guarantee that he or she would command the same recognition of expertise. The competitive work culture also seemed to discourage some local unofficial experts from spending too much time helping others. The local unofficial experts felt that they needed to concentrate on improving their own performance ratings by resolving as many cases as quickly as possible.

6.8 Methodological Considerations – Part C

The various methodological tools incorporated in the AODM so far have made it possible to inform the systems design processes of gathering and analysing data from an AT perspective. Whilst the presented AODM tools enable the designer to acquire an understanding of a situations being studied using Activity Theory, methodologically it is still not clear how the various techniques come together. In order to address this issue, the idea of showing how the various AODM techniques map onto each other (see Figure 11) was conceptualised. This realisation marked the development of the approach to represent visual mappings of AODM operational processes. Another contributing factor

to this idea emerged as a result of representational challenges experienced when trying to show time dimension of the existence of temporary relationships and contradictions identified following the analysis of work practices at Comptel. These representational challenges are discussed as follows.

Representing time dimensions of temporary relationships

The operation of a job rotation system at Comptel meant that new temporary relationships and cultural norms were forged amongst workers in teams. Whilst temporary relations may exist for a limited period of time, they tend to make important contributions to the transformation and transition of an activity system. In addition, temporary relations can also affect the translation of an activity system under investigation. The problem experienced when dealing with this issue lies in the difficulty in representing these temporal relations on the triangle model in a way that is meaningful for the purpose of translating and communicating what is happening. In this regard Engeström (1987; 1999) has made important contributions by introducing a layered approach to modelling activity systems. It could be argued that Engeström's approach to modelling activity systems help to visualised and comprehend the developmental perspectives or transitions of an activity system from state to another. However, this innovative approach to modelling activity systems does not explicitly reflect the time span or duration for the existence of observed relationships. It is however also worth mentioning at this point that neither does the AODM incorporate a well-worked technique for representing time dimensions to show the existence of relationships in an activity system.

Representing identified contradictions in work practices

Further representational problems were identified when trying to show identified contradictions in Comptel work practices using the traditional activity triangle model. The main difficulty in this regard emerged when trying to represent several contradictions

on the model. Several researchers have adopted their own methods for showing contradictions using the activity triangle model. For example, Engeström uses a '*lightning-stroke*' like symbol to indicate one or more contradictions (see e.g. Engeström 1999, pp.30-31). Representation serves communication purposes in design, it is therefore important to have a standard or systematic modelling approach to representing analytical findings. Multi-representational approaches that are not well explained or systematically structured can be confusing to someone trying to make sense of what is being communicated in the model. The problem here is that it is difficult to tell whether the contradictions exists *within* a sub-activity system or the main activity system, or even *between* two sub-activities within a single main activity systems. To address some of the outlined representational problems, I developed a slightly different approach to representing contradictions. This involves mapping operational processes to show how the various stages involved when using the AODM approach come together. This is shown in Figure 12 and explained as follows.

On the left hand side of Figure 12 is a representation of a broken down activity system consisting of various sub-activities. The next column in the figure shows the activity system with the sub-activity triangle being focused on highlighted by using lines. The next column gives examples of research questions that can be generated in relation to the focused sub-activity triangle. Thereafter, connecting arrows pointing to various entities in column showing possible areas of contradiction. Therefore, through the introduction of pointer arrows between entities, this approach makes it easier to visualise the mapping between the main activity system, the sub-activity triangle being focused on, the research question, and, the possible area of contradiction. Figure 12 illustrates this approach in relation to findings of the analysis of work practices at Comptel.

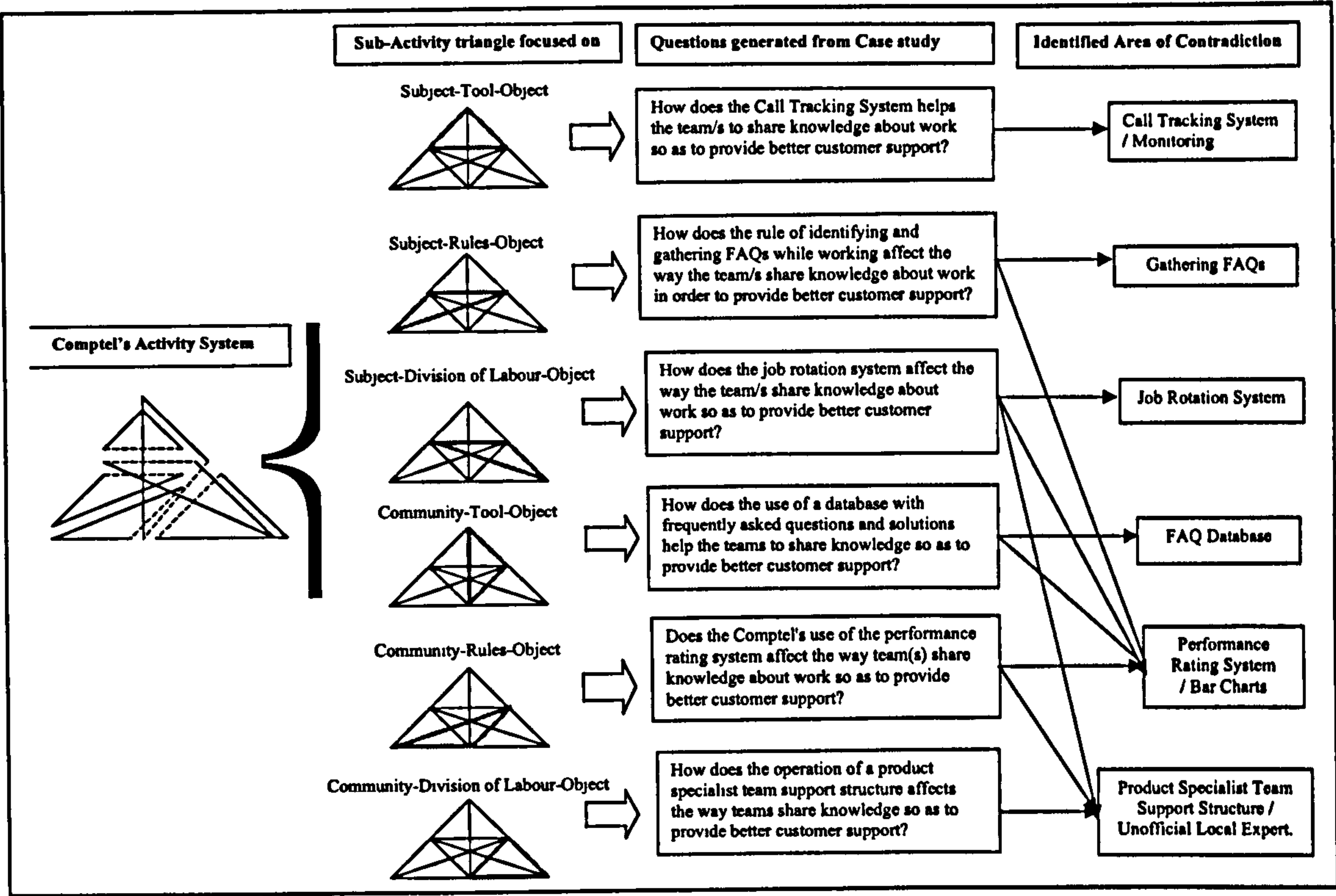


Figure 12: Mapping AODM Operational Processes

6.8.1 Development of the technique of Mapping Operational Processes

The AODM approach shows the mapping between identified contradictions and the sub-activity system in which that contradiction exists. The AODM representation also includes the use of arrows pointers to shows the link between the generated research question and the relevant sub-activity triangle focused on (shown in orange). The link between the sub-activity triangle focused on and the identified area of contradiction is also shown. The AODM representational approach does not solve all the problems of representing contradictions on the triangle model, but at least it gives a clear indication of the number of contradictions identified in a particular sub-activity *within* a single

system. This is achieved by simply counting the number of arrows coming from the sub-activity focused on. Finally, the AODM representation shown in Figure 12 also makes it easy to conceptualise the operational structure of the method by making the incorporated operational processes diagrammatically explicit.

6.9 Conclusion

This chapter has explained and empirically demonstrated the iterative development and application procedure for the various tools incorporated in the AODM using Comptel organisation as a test bed. In so doing, the chapter begun by demonstrating and explaining the means by which the *Eight-Step-Model* developed in chapter five was used to gather data about work practices at Comptel. During data analysis, certain method considerations or challenges emerged that inspired the development of additional tools to be incorporated in the AODM. These additional tools included the development of the *Activity Notation* (incorporates ‘three operational guidelines), the technique to *Generating Research Questions* and finally the representational technique to *showing visual mappings of AODM operational processes*. This chapter therefore, marks the end of the description of the development of all the tools incorporated in AODM. The next chapter will be focused on demonstrating and describing the means by which the complete suite of AODM tools can be used during systems design. Here I will re-visit EngiCom organisation to conduct a focused and detailed analysis of work practices at team level using the AODM tools developed and outline in the last two chapters.

Chapter Seven

7. AODM Development Phase 3 – EngiCom Teams

In the last two chapters (chapter five and six), the thesis progressively developed the various methodological tools incorporated in AODM namely: the *Eight-Step-Model*, the *Activity Notation*, the technique for *Generating Research Questions* and *Mapping Operational Processes*. The current state of AODM is such that it addresses the methodological challenges outlined in chapter five (see section 5.) by:

Data gathering

- Using the Eight-Step-Model to focus the investigation on a specific activity of interest.
- Supporting data gathering through the generation of general and specific research questions that can be used in questionnaires, observations, and interviews.

Data Analysis

- Supporting systems decomposition using the Activity Notation to reduce complexity during data analysis. This is achieved by producing sub-activity systems to work with thereby facilitating levelled abstractions when analysing human activity.
- Supporting data analysis by guiding the process of identifying contradictions *within* and *between* sub-activities of an activity system. This is achieved by using the technique to generated research questions for use as pointers to issues and areas to focus on during data analysis.

Communicating acquired insights

- Facilitating the communication of acquired insights from the investigation as part of the systems design process. This is achieved by using the Eight-Step-Model to model the situation's activity system, thereby translating the situation being

examined in terms of Activity Theory. The produced activity system also shows the various components incorporated within.

- Facilitating ease of method comprehension by introducing the technique for mapping operational processes thereby making AODM application procedure explicit.

This chapter reports on the second empirical analysis of work practices at EngiCom organisation. The study investigated team-based work practices following the introduction of the Enrich system (Figure 8 in section 5.2.2) to mediate work practices. One of the key aims of this study was to establish team perspectives about work practices in this organisation and mediators that were in use prior to the introduction of the Enrich computer system. This chapter is therefore focused on describing team-based work practices from the workers' point of view. Discussions of management's perspectives on work practices in this organisation were reported in the initial study of EngiCom work practices presented in chapter five. This approach to investigating work practices in the same organisation at different levels of operation provides a comparative conceptualisation of work practice reflecting both management and workers' views. In addition, this approach makes it possible to identify contradictions or discrepancies *between* management's view and the workers' view, which may affect the way work activity is carried out. See for example, interview transcript on Appendix B – 1 (pages 278 and 279).

The investigation procedure was conducted as follows. The study used AODM tools outlined above to investigate team-based work practices in this organisation following the introduction of the Enrich computer system. Discussions in this chapter begin by describing how the Eight-Step-Model was used to aid the process of gathering and interpreting data about team-based work practices at EngiCom. These discussions systematically demonstrate how the Eight-Step-Model was used to translate the various components of the activity triangle model by italicising and underlining the activity triangle component being translated as shown in section 7.1. A comprehensive translation of EngiCom teams' activity system is given in section

7.2 with components shown in bold headings. This is followed by the data analysis section (section 7.3), which presents a critical review of EngiCom's team-based work practices. These discussions also describe how the *Activity Notation* was used to decompose EngiCom's team activity system so as to reduce complexity and facilitate a detailed analysis of relationships *within* and *between* sub-activities of this system. These discussions also demonstrate the means by which the technique of *Generating Research Questions* was used to support the analytical process of identifying contradictions in the perception of work activity between management (discussed in chapter five) and workers' understanding of practices in this organisation. In so doing, this chapter demonstrates the means by which the various tools incorporated in AODM can be used to support work analysis and guide the design processes of gathering, analysing and communicating design information during systems development.

7.1 Data Gathering

The task of gathering data about team-based work practices at EngiCom using the Eight-Step-Model was conducted as follows. The initial task was to identify a specific 'activity of interest' to focus on during the investigation. In this regard, the 'activity of interest' was selected from the general information gathered about EngiCom's work practices described in chapter five. The activity of interest to the researcher was identified as that of understanding knowledge sharing practices amongst team members at the lower operational level (see Figure 7 in chapter five) using Activity Theory. The identification of the 'activity of interest' helps to focus the study by defining the *context* of investigation. With regards to this study, this meant identifying a specific 'plant' or manufacturing site and teams whose work practices to investigate during the focused study. In this case *two teams* operating at two separate 'plants' (manufacturing sites) based in two different locations were selected for focus during the study. The selection of these two teams and manufacturing sites was based on the general information gathered about EngiCom work practices in chapter five. The study was conducted at the manufacturing sites where workers of the two selected teams normally operated. This meant that several

visits had to be made to these plants so as to ethnographically study work practices in these two teams in context. After establishing the context of study and identifying the ‘activity of interest’, the next task was to establish team workers’ shared objective for engaging in knowledge sharing practices. The *shared objective* was identified as that of wanting to learn from each other’s work experiences. The desired *outcome* from the workers’ knowledge sharing activities was to provide better technical support.

The rest of the data gathering process involved working through the remaining open-ended questions presented in the Eight-Step-Model so as to gather basic information about team-based work practices at EngiCom. Open-ended questions incorporated in the Eight-Step-Model were used to point the researcher to the kind of activities to focus on during observational studies and also as guidance to the type of questions to ask during semi-structured interviews with workers. Observational studies involved shadowing in the manufacturing plant whilst workers carried out their duties and also attending team meetings. Semi-structured interviews involved holding discussions with team leaders and team members who had key roles to play within the team structure. Further information about team work practices was gathered through informal discussions with workers in general in more relaxed environments for example in staff canteens during lunch breaks and at pubs. The data gathering section (see 5.2) in chapter five, discussed how a proxy was engaged to access classified information. However, the fact that the proxy was based at EngiCom headquarters operating at middle management level (see Figure 7 in section 5.2.1) meant that this study could not fully benefit from his insights because he was not very familiar with the social and cultural aspects of team-based work practices. As a result of this, the proxy was used during this study to introduce the researcher to team leaders and other key individuals amongst team workers. These introductions enabled the researcher to forge new ‘work relationships’ with workers for the purpose of clarifying emerging issues about team-based work practices. The introductions also eased the atmosphere when observing team workers carrying out their duties during the study. Data gathered was qualitative in nature. In terms of

data recording, the researcher made notes during interviews and observational studies. The researcher also maintained a research journal used to record clarifications of information gathered in social settings i.e. lunch breaks and company document review. The information gathered represents a translation of the various components of the activity triangle model in relation to EngiCom's team-based work practices under investigation. Following this data gathering process, a description of EngiCom team-based work practices is presented in the section below.

7.1.1 EngiCom's Team-based work practices

The main responsibility of the two teams investigated at EngiCom was to provide technical support to engineers by producing technical manuals and online support information. This support information outlined the assembly and operation mechanisms of the various manufacturing components used in this organisation. In addition to this, team workers were also required to continuously review their performances against the five company values outlined in chapter five (see section 5.2). Chapter five also discussed how management at EngiCom had introduced use of the company workbook to guide the performance assessment procedure. This involved use of the 'value planning sheets' and 'value scoring matrices', both of which are incorporated in the company workbook so as to guide and standardise work procedures through out the organisation. However, team workers did not use the company workbook as intended by management. Instead, they used it as a reference manual from which to generate their own ideas and methods of assessing team performances against the five company values (see for example, interview extract in Appendix B-1, on page 279). Team workers did however, take into consideration the extent to which their chosen techniques for carrying out the value planning and performance assessment exercise fits in with management's recommended method as presented in the workbook. Some of the value planning and performance assessment methods employed by team workers involved a technique referred to as the 'Plan-Do-Review' process. This is illustrated in Figure 13.

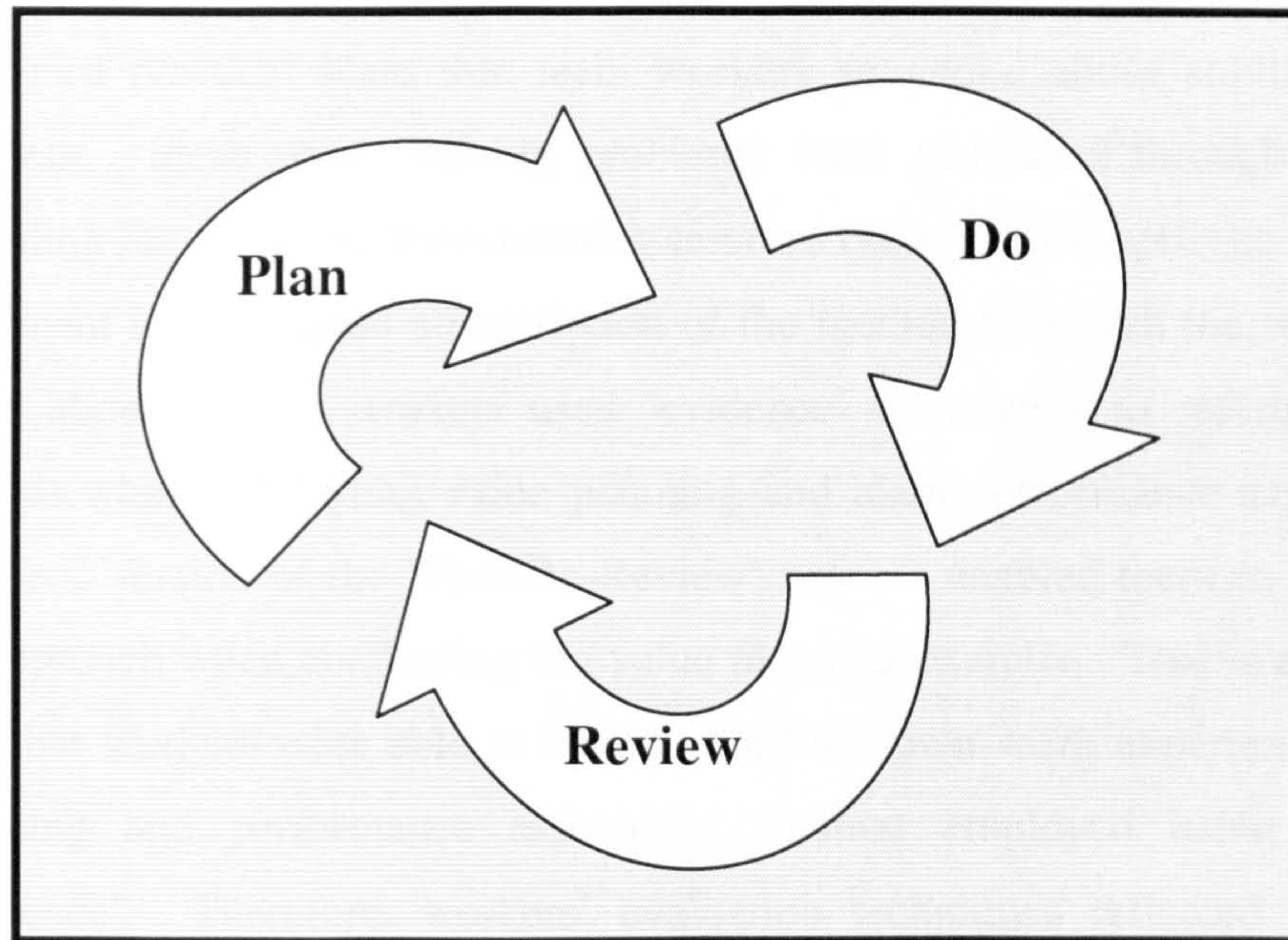


Figure 13: The 'Plan-Do-Review' process

The 'Plan' part of the 'Plan-Do-Review' process reflected the stage at which a team plan was generated to outline the objective and set targets to be met in relation to a particular company value. The 'Do' part of the 'Plan-Do-Review' exemplified the kind of actions to be taken in order to achieve the objective set out in the plan. Finally, the 'Review' phase indicated the type of performance measures to be used to evaluate and rate team performances against targets set. When using the 'Plan-Do-Review' technique during the team value planning and performance assessment exercise, a team leader normally worked out a plan on how the assessment is going to be carried out. This involved setting an objective and targets to be met with regards to a particular company value. In preparing the plan, the team leader would draw from previous experiences, higher-level plans and current operations to be carried out within the team. Once the team leader has worked out the plan, the rest of the team members participate in the actual 'do-ing' of the assessment and 'review-ing' team performances. During the 'do-ing' and 'review-ing', team members would hold semi-formal discussions relating to their performances and progress on a

particular topic connected to the company value being assessed. Identified problems were recorded together with solutions applied or to be applied in a document referred to as 'evidence'. The notion of 'evidence' referred to a paper-based document used to record practical ideas that team workers generated about solving an identified problem. Ideas about solving problems were generated through various means including for example, brainstorming sessions during team meetings. The 'evidence' document also included a description of the method by which the recorded solution came about. Team workers used 'evidence' documents as reference material to consult when conducting value planning and team performance assessments. The workers' version of the 'Plan-Do-Review' process enabled them to apply a bottom-up approach when conducting the value planning exercise. This is evident from the fact that workers were able to incorporate their own work experiences in the value planning and performance assessment method employed using the notion of 'evidence'. Therefore, workers' evaluation techniques reflected team members' work experiences and established cultural norms.

In addition to the concept of 'evidence', other knowledge sharing practices employed by team workers at EngiCom were mainly informal and unstructured. For example, team workers informally consulted each other whilst working, a tendency that resulted in the recognition of certain members of the team to be 'specialists' in particular areas of operation. For easy of reference, I decided to call these specialists 'unofficial local experts'. 'Unofficial local experts' were fellow team workers recognised for their expertise and willingness to help other workers with work related problems. In terms of structure, a team included temporary staff from employment agencies. The organisation engaged services of temporary workers from employment agencies from time to time. Temporary workers or 'temporary staff' as they were referred to had no fixed duration of employment. Therefore, management at EngiCom had decided to restrict temporary staff's access to classified information.

7.2 Communicating acquired insights about EngiCom Teams

The information gathered about team-based work practices at EngiCom was interpreted in terms of Activity Theory through the production of an activity system to represent the investigated practices. This data interpretation involved the use of the Eight-Step-Model to map out the various components of EngiCom team activity systems from the information gathered about team-based work practices. The purpose of this data interpretation was to communicate the acquired insights about EngiCom’s team-based work practices back to the workers so as to verify the accuracy of the information gathered. The team-based activity system for EngiCom organisation is presented in Figure 14, with the various components discussed thereafter.

7.2.1 EngiCom teams activity system

Figure 14, shows the activity system reflecting team-based work practices at EngiCom.

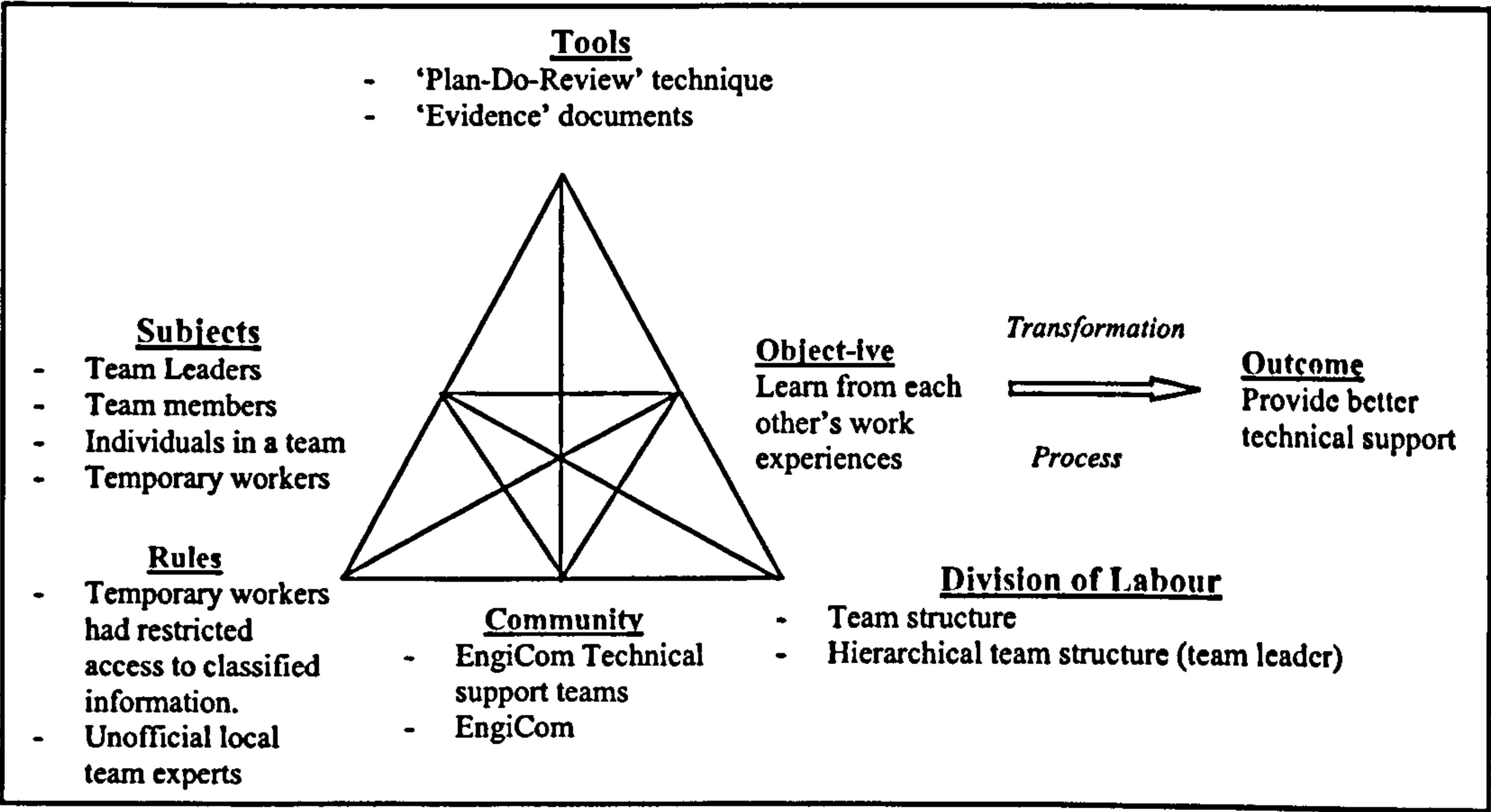


Figure 14: EngiCom Team-based activity system

The various components of EngiCom team-based activity system are discussed as follows:

Activity

The *activity of interest* to the researcher was identified as that of understanding *knowledge sharing* practices relating to the value planning and performance assessment exercises.

Object

From the workers' point of view the main *objective* for sharing knowledge was to *learn from each other's experiences*.

Outcome

The desired *outcome* from this activity system as perceived from team workers' point of view was to *provide better technical support* to engineers in this organisation.

Subjects

Subjects engaged in the activity of sharing knowledge about value planning and performance assessments were identified as team members working as a group. 'Team members' include a team leader, individuals working own their own or in a group within a team, also temporary workers from employment agencies working as part of the team.

Mediators (Tools, Rules, Division of Labour)

The kind of mediators used during team activity include the following: the 'Plan-Do-Review' technique, 'evidence', cultural norm of consulting unofficial local team experts, the rule to restrict temporary workers' access to classified information, also the hierarchical organisational structure of team responsibilities (division of labour).

7.2.2 Decomposing the team’s activity system

Following the production of the team activity system, there was a need to conduct a critical analysis of the relationships that existed *within* and *between* the various components representing team-based work practices in this system. To facilitate this detailed analysis, the *Activity Notation* (see Figure 8 in chapter six) was used to decompose the team activity system so as to reduce complexity by generating sub-activities to work with. The sub-activities produced from this decomposition process were thereafter used to *generate research questions* that are specific to the two teams selected for focus during the detailed investigation. Table 13 presents examples of specific research questions generated for the purpose of conducting a detailed analysis of team-based work practices at EngiCom.

7.2.3 Generating research questions

Examples of specific research questions generated for EngiCom Teams
<div><div>-</div><div>How does the Plan-Do-Review (<i>tools</i>) technique help team members (<i>subjects</i>) to learn from each other’s experiences (<i>object</i>)?</div></div> <div><div>-</div><div>How does the use of the ‘evidence’ document (<i>tools</i>) help team members (<i>subjects</i>) to learn from each other’s experiences (<i>object</i>)?</div></div> <div><div>-</div><div>How does the team structure (<i>division of labour</i>) affect the way team members (<i>subjects</i>) learn from each other’s experiences (<i>object</i>)?</div></div> <div><div>-</div><div>How does the use of an unofficial local team expert (<i>rule / cultural norm</i>) help team members (<i>subjects</i>) to learn from each other’s experiences (<i>object</i>)?</div></div> <div><div>-</div><div>How does EngiCom’s (<i>community</i>) rule of restricting temporary workers’ access to classified information affect the way team workers learn from each other’s experiences (<i>object</i>)</div></div>

Table 13: Specific Research Questions Generated for EngiCom Teams

7.3. Data Analysis -Conducting a detailed investigation

In order to conduct a critical analysis of team-based work practices in this organisation two key relationships considered crucial to the success of learning from each other's experiences were identified and selected for focus. These relationships are outlined as follows:

1. The relationship *within* and *between* team members(s) (*Subjects*) and the team objective of learning from each other's experiences (*Object*).
2. The relationship *within* and *between* EngiCom (*Community*) and the team objective of learning from each other's experiences (*Object*).

During the analysis, the study focused on establishing the means by which various mediators of team-based work practices especially those outlined in the EngiCom team activity system affect the two relationships highlighted above. This entails identifying possible contradictions or problems that emerge *within* and *between* team operations (sub-activities) as a result of using or the existence of these mediators in team activity. In addition, by analysing the mediational aspects of the two relationships highlighted above, it was possible to uncover contradictions that emerged as a result of differences *between* EngiCom (*Community*) management's and team workers' perspectives about work practices in this organisation. Detailed discussions about identified contradictions are presented in the section that follows hereafter.

7.3.1 Data Analysis - findings of team-based work practices

Chapter five discussed how management at EngiCom had introduced the use of a company workbook in an effort to standardise work practices and encourage knowledge sharing amongst workers in this organisation. However, the analysis of team-based work practices revealed that workers at team level did not use the paper based company workbook (see section 5.2.1) as intended by management. Instead, team workers used the company workbook as a reference manual from which to

generate ideas on how to develop their own strategies for conducting value planning and performances assessment exercises (see Appendix B – 1, page 279). The development of the ‘Plan-Do-Review’ technique to aid the value planning and performance assessment process is one such example. According to findings of this study, workers felt the company workbook imposed a rigid top-down work structure that didn’t reflect or account for their already established methods of working. The workers’ version of the ‘Plan-Do-Review’ technique on the other hand employed a bottom-up approach that reflected workers already established methods of working. Workers perceived the standardisation of the value-planning and performance assessment exercise through the introduction of the workbook as a disturbance to their already established styles of working. These findings are reflected in the following interview response given by two team leaders when asked whether they used the company workbook during their work activity.

Interviewer: Are there tasks in which you use the paper-based company workbook or part of it?

Respondent A: No, we don’t use the workbook at all. We produced our own tailor made techniques from the workbook that suits our needs and working style.

The original workbook is used only as a main source reference manual for teams to formulate their own plans ideas. One of the problems with using the old workbook is that there was no way of linking or getting feedback on the success or failure of its usage. There was no way of telling whether or not other teams are using it, and even if they are, it is difficult to find out how they are using it. Once we were asked to use it [company workbook] by management, the first reaction was to ask ourselves, what is wrong with the way we work now? Why introduce new guidelines for team value planning?

A second respondent who was a key member of the people value team expressed similar views when asked to explain how they work and use either the company workbook or the Enrich system.

Interviewer: Can you tell me what your team does and may be how you use either the company workbook or the Enrich system?

Response B: I am responsible for organising group team meetings for the people value team. We have developed our own method of planning using ideas from the paper-based company workbook. We do not use the new tool [Enrich system] during our planning. We feel the new tool is something pushed onto us from above [management]. We see the introduction of this new tool as an extra gadget that will introduce extra work. There is really no motivation to use it all. Morale is quite low at the moment because of what is going on in the organisation. A lot of changes and re-organisations are taking place at the moment such that people don't know whether or not they will have a job next month, so why get excited about a new system if you don't know *whether you will be here or not.*

The response given by the second respondent raise a lot of design issues *that may or may not be immediately evident to the systems designer until a contradiction occurs in the usage or workers' perceptions about the usefulness of the system.* For example, by introducing the company workbook, EngiCom workers felt management was trying to control and impose new methods of working. Therefore, the fact that the design and functional implementation of the Enrich system was based on the company work created a negative perception of the usefulness of the tool. The resulting effect was that workers did not want to use the system. In addition to this, the second respondent also expressed concerns about job security and the lack of motivation from management to use the tool. Workers' concerns about job security reflect environmental issues that must be addressed during systems design. Even

though these environmental factors may not seem relevant to the design task, evidence from this study indicate that they can influence the way workers perceive the usefulness of a computer system.

Contradictions were identified when analysing the two key relationships (first discussed in chapter six, see section 6.7) considered to be crucial to the success of learning from each other's experiences. Notably, EngiCom's rule of restricting temporary workers' access to classified information caused some contradictions in the workers' knowledge sharing practices. Even though both permanent and temporary workers performed similar tasks, it was difficult for them to learn from each other's work experiences because they did not have equal access to information resources. Permanent workers had to be cautious as to the kind of work related information they divulged to temporary workers due to restrictions in the company regulations. This observation is also apparent in an interview response given by one of the team leaders when asked to give reasons for not using the Enrich system.

Interviewer: What would you say is the main reason for not using the company workbook and the Enrich system?

Respondent A: There are many reasons. To start with, our team members tend to work hand in hand with long term temporary staff hired through employment agencies. It is therefore difficult to give everybody equal access to all functions of the tool [Enrich system] due to differences in working terms and conditions. Then there is also the duration of contract for temporary staff, it just makes difficult to give equal access for security reasons even though they do the same job as the permanent EngiCom staff.

A contradiction emerged from the fact that workers could not effectively learn from each other's experiences because temporary workers did not have equal access to work related information due to company restrictions.

Another contradiction that was identified which affected the usage of the Enrich computer system in relation to supporting collaborations amongst team workers was the fact that the system's interface mirrored the layout and presentation style of the paper-based company workbook. Since Enrich was developed and implemented based on the company workbook, employees were reluctant to use it because they viewed it as management's way of controlling not only what they did but also how they did it. They argued that, just like the paper based company workbook, the new computer system did not take into consideration local established methods of doing things.

Further contradictions emerged as a result of a misrepresentation of team local culture in the way the Enrich system supported knowledge sharing activities amongst team members. Management's version of how teams shared knowledge in this organisation presented 'best practices' as the main source of knowledge that workers consulted during work practices. The Enrich system was therefore implemented with a link to a database of best practices so that team members could access and refer to them during their team planning process. However, findings from the analysis of team-based work practices revealed that teams never consulted these best practices at all. They had instead what they referred to as 'evidence'. The idea of 'evidence' in this context refers to an individual or a document containing facts about how to go about carrying out a particular task. Team members did not find the best practices particularly useful because they did not include the context and process by which these lessons were learnt. Instead, the idea of 'evidence' was much preferred because it incorporates the methods and explanations of how the knowledge came about. This observation provides one way of demonstrating how Activity Theory leveraged this investigation by highlighting user-specific behaviour and contextual issues that impacted on the usage of what was considered by Enrich designers to be a powerful knowledge sharing tool – best practices database. Instead of using the database of best practices, workers at team level found it easier to identify and relate to the notion of 'evidence' because it incorporated local practical ideas that

developed from team members' experiences. Consider for example the following interview discussion that re-iterates the significance of established local cultural practices when sharing knowledge amongst workers:

Interviewer: So what do you think about the tool as an individual who has had chance to 'play' around with it and use it?

Respondent A: In my opinion, the new tool is not very useful for searching 'best practices' because these can change from time to time. Besides, we never consulted 'best practices' anyway. We don't always refer to what other people have done anyway. For this reason, even the sharing of knowledge element of the new tool [Enrich system] is not valued much, even though benefits could come to be appreciated once the tool has been widely used. In my view, the main uses of the new tool lie in the storage, access and distribution of documents. The only problem at the moment is the lack of usage by team members, maybe because they view the tool as another venture from management. EngiCom has been getting involved in many projects that have ended in failures within periods of six months or so. You see, these systems seem to be driven from the top to the bottom. At the bottom level it only works when there is a belief that it is a push from down to the top, which is the case with the idea of using 'evidence' to share knowledge about work.

The significance of local established culture seems to have influenced workers' perceptions about the meaningfulness and usefulness of the Enrich systems interface. In this regard, contradictions were identified in the way team members interpreted the functional aspects of interface features of the Enrich system. This in turn affected workers' judgement about the usefulness of the Enrich system to their work purposes. This is reflected in a comment made by one of the team leaders who

suggested that the systems interface be changed to include a colour-coding scheme for representing the company values on the systems interface.

Respondent A: We made a request for the tool [Enrich system] to facilitate the colour coding of the five values in the value plan to fit in with our working style. You see, we can easily identify each value by its own colour. For example, we already use coding to represent and differentiate company values in the ‘evidence file’. This could also be supported in this tool. The different colour coding schemes that we use are as follows:

Red	-	used to represent ‘Customer Value’
Blue	-	used to represent ‘People Value’

We selected and agreed on the use and meaning of this colour scheme as a team. The use of these colours is meaningful and informative to us. We would therefore prefer it if the system had the same colours for company values.

The team wanted to extend this local cultural norm of colour coding company values in the ‘evidence file’ to the interface representation of company value information on the Enrich system. They argued that these colours had interpretive and functional meanings to workers. The colour coding scheme therefore facilitated a communicative design aspect that was not necessarily in line with acceptable HCI usability criterion but was informative and useful to team workers. For example, the team selected a red background with yellow fonts to represent the ‘customer value’, a blue background with yellow fonts to represent the ‘people value’ on the interface of the Enrich system. Figure 15 shows a screen snapshot of the coloured interface representation of the ‘company value’ and ‘people value’ information chosen by team workers.

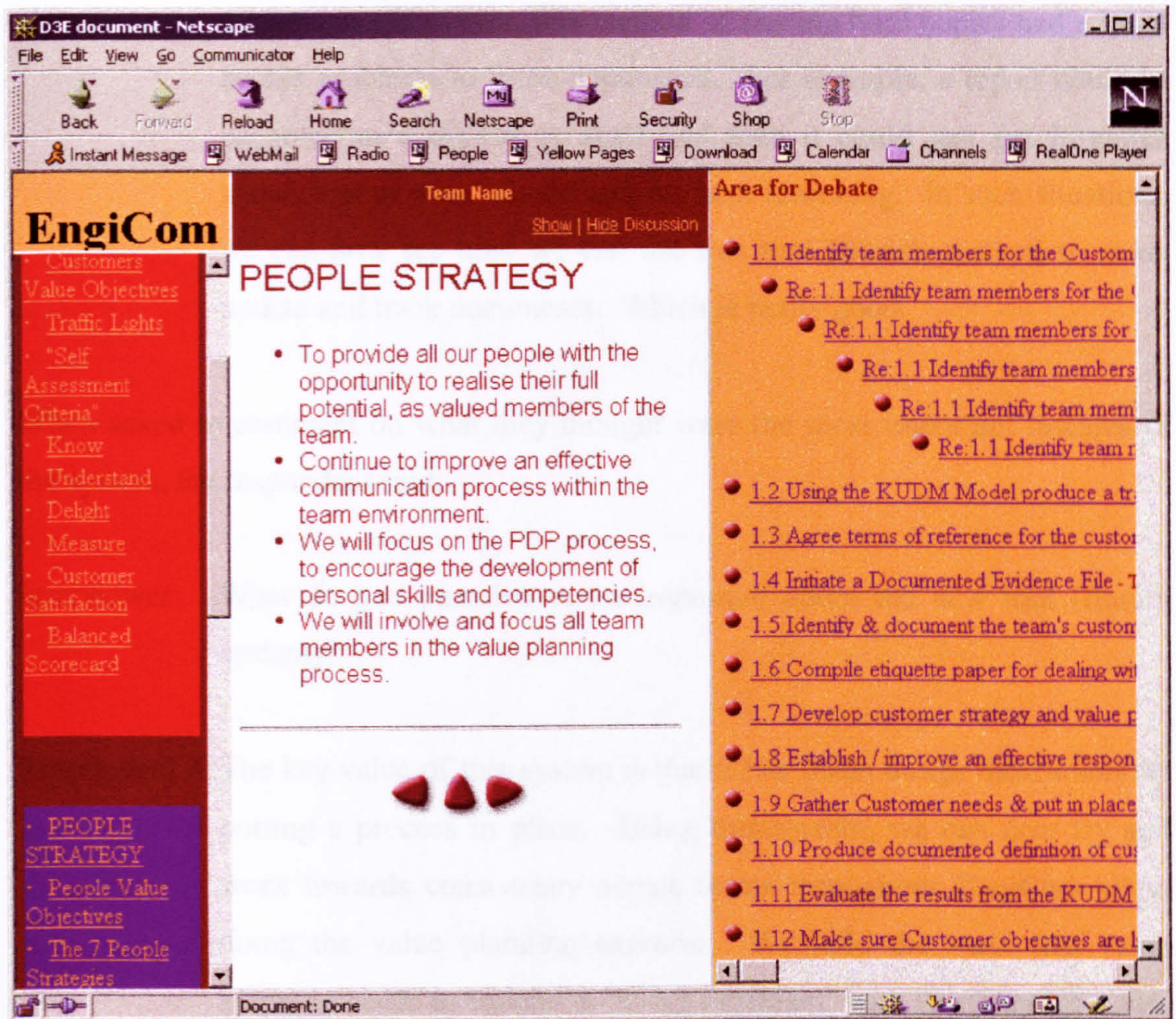


Figure 15: Colureful Enrich systems interface selected by EngiCom workers

As a result of the identified contradictions in the representations and support mechanism for established team local cultural practices, workers began to envision alternative ways of using the Enrich system to make it more useful to their purposes. For example, one of the team leaders noted how the system could be used to support the storage, updating and distribution of ‘evidence reports’ and team newsletters.

Respondent A: We believe the earlier ‘best practices’ and ‘discussion area’ functions of the Enrich system didn’t serve us well. We therefore started thinking about alternative uses of the tool [Enrich system]. In our old method of working we depended on sharing and hard copies of

documents. However, this method of sharing hard copies had a lot of access problems to these documents. For example, a report could be on someone's drawer or shelf and then it could just get forgotten about, lost or even missed and we kept searching. In such situations, we can now see how we can use this tool [Enrich system] to store, update and track documents. Which is really good.

When asked to comment on what they thought were the most important features of the system, the respondent said:

Interviewer: What do you perceive to be important about the new tool [Enrich system]?

Respondent A: The key value of this system is that it has made things measurable by putting a process in place. Using this system, we can now try and work towards consistency across teams throughout EngiCom when doing the value planning exercise. We hold the view that value planning needs to become a 'living organism' with flexible objectives. The objectives that were originally set may change later on in the year. Therefore we need a tool that can allow us to review our value plans on a regular basis instead of annually. The new tool [Enrich system] will also be good for generating initial plans. For example, the system can be used to support brainstorming activities using the 'discussion space' [debate area], which can be conducted prior to the actual meeting.

The other advantage of using this electronic version of the paper company workbook results from the convenience of being able to make changes directly and locally not through someone at headquarters. Then there is also the possibility of sharing documents e.g. a hard copy document can be transferred from one person to

another in electronic format. It is really too early for us to comment on benefits of using the tool [Enrich system] because even though the tool is now available and accessible for use by everybody, there is lack of usage.

Interviewer: I understand you have had a try at using the new tool, do you think there are benefits to using it within your team or maybe on other teams that you collaborate with?

Respondent B: Oh yes, I can see the benefits of using the new tool [Enrich system] quite alright. It would be particularly useful for distributing documents and especially linking to 'evidence'. Unlike the paper-based company workbook, using this new tool also makes it easy to find relevant information.

The main reason why most people are not using it even though they have heard about it and seen it is due to lack of motivation from management. We feel that there are already too many things to do. The atmosphere in the organisation is leading to lack of motivation in using the new tool. Team members are uncertain about their jobs. There is a lingering threat of redundancies. Members feel they already have enough to do as it is. We don't understand why we should be given extra responsibilities of using a new tool that is also seen as a management's toy. If management want us to use it then they need to motivate us. As I mentioned earlier, we have not even had our 'people value' plan meeting for two months now. It is so chaotic at the moment.

In terms of knowledge sharing, the use of a computer system introduced uncertainties as to who should access what information due the organisation's use of temporary staff. The second investigation discovered that the organisation engaged

the services of temporary staff from employment agencies from time to time. Temporary staff had no fixed duration of employment therefore management decided to restrict their access to classified information. Their duties were also heavily monitored and controlled. Even though it was possible to control access to classified information by requiring users to log-in and using passwords, this strategy could not have worked because knowledge sharing tends to succeed where it is inclusive. In this case, workers did not have equal access to resources.

In terms of collaboration, social and cultural practices of workers at team level were not appropriately supported by the computer system an aspect that affected the usage and acceptability of this tool. For example, team members had developed a local cultural habit of discussing work related problems collaboratively by consulting a local unofficial expert within the team in a face to face arrangement if the problem was urgent. If the problem was not urgent, they would wait and raise the problem for discussion during the next team meeting. A local unofficial expert in this context usually referred to a fellow worker recognised by others to be more knowledgeable about manufacturing operations in this organisation and also willing to help others once a problem emerged. The kind of collaborations and consultations that normally took place amongst team workers in this organisation were mainly informal and unstructured. The Enrich computer system tried to emulate this process by introducing a discussion space to support similar discussions and collaborations, so that these could be captured, stored and accessed by all employees in the organisation. This effort resulted into a mis-representation of established local cultural habits of by formalising discussion and collaborations that were normally informal and conducted in confidence. Team members were therefore not keen to use the system because they did not like the idea of discussing online when they could see each other and hold discussions face to face. The fact that the computer permanently captured discussions for future reference also contributed to its lack of usage because workers were worried about exposing their views, as they did not know who else was going to read their contributions outside the team.

Finally, regarding management's idea to introduce a hyperlink from the form-based interface in the Enrich system so as to link all levels of operation, team workers were keen to use this feature because they wanted to establish how their activities at team level feeds into management's overall objectives. However, this feature was also under-used due to management's failure to put content on their part of the tool.

7.3.2 Reflections on findings

Traditional HCI design approaches to gathering and analysing user situations tend to focus on eliciting information that enhances the usability of the resulting system. Whilst usability of a system is undoubtedly a vital determinant of the usefulness of a computer system, the Activity Theory informed analysis of the user situation in this study have revealed non-traditional usability issues that have had an impact on both the design and usefulness of the Enrich system. The outlined findings highlight the significance of established local cultures of the context of deployment for the system being built. These local cultures tend to have contextual interpretations that bear meaningfulness and usefulness of a computer system to the purpose of use. For the systems designer, an awareness of these local cultures can contribute significantly to the development of meaningful interface and functional features and usefulness of a computer system to the purpose of use.

Findings indicate that, the use of AODM to gather and analyse user situation can help or enable the designer to establish and account for these issues during the early phases of systems design.

7.4 Conclusion

In this chapter, the thesis has empirically demonstrated the means by which the various tools incorporated in AODM can be used to support the design processes of gathering and analysing data during the early phases of systems development. The illustrated AODM approach to systems design extend the traditional HCI usability efforts by enabling the designer to address issues relating to the usefulness of the resulting system in relation to the context and purpose of deployment.

In this regard, chapter seven also concludes discussions about AODM development and application procedure. The next chapter will describe the validation approach used to assess and determine the conditions for the utility of AODM.

Chapter Eight

8. Towards an Activity-Oriented Design Method for HCI research and practice

“The greatest invention of the nineteenth century was the invention of the *method* of invention. A new method entered into life. In order to understand our epoch, we can neglect all the details of change, such as railways, telegraphs, radios, spinning machines, synthetic dyes. We must concentrate on the method itself; that is the real novelty, which has broken up the foundation of the old civilisation” (Whitehead, 1970).

The computer systems design process like any other creative activity varies depending on the type of product being developed and available resources. Key to this activity is the method used to guide the design process. Over the years, various computer systems design methods have been introduced. These include but are not limited to the ‘waterfall model,’ which represents the traditional approach to software engineering, right up to the HCI design model, which emphasises user-centeredness throughout the systems design and development process (Norman and Draper, 1986; also discussed in chapter two of this thesis). Even though differences do exist in their execution mechanisms, most design methods are targeted towards solving particular design problems. For example, the HCI design model in its traditional form is focused on ensuring the usability of interface features of the resulting computer system. However, currently existing HCI design methods are increasingly being criticised for neglecting issues relating to the usefulness of computer systems so as to help the user to achieve desired goals (see chapter one and two). Such criticisms emerge due to the fact that a design method that is used during systems development can determine the usability and usefulness of the resulting computer system. As a result, there has been a reassessment of the systems development process, which has triggered a search for innovative methods to inform HCI design. The kind of methods required for use within HCI are the ones that

enhance currently available techniques for conceptualising computer tool users, their activity, and, the environment in which activity is carried out. This thesis has investigated and developed such a method from Activity Theory, as discussed in chapters four, five, six and seven. Chapters five, six and seven have also demonstrated the means by which the proposed method can be systematically applied to gather, analyse and model complex data about human practices in an organisational setting. The Activity Theory informed design method proposed in this thesis has been named the “*Activity-Oriented Design Method*” for HCI design or just the acronym “*AODM*”.

Chapter Eight will now presents a complete description of AODM as illustrated in section 8.1. Further sections will discuss and outline the validation procedure employed to verify the utility of AODM in HCI design. AODM is intended for use during the early phases of the systems development process to support requirements capture. The method provides an Activity Theory based mechanism for gathering and analysing data for systems design purposes. Thereafter, AODM supports the design process of communicating acquired insights through modelling so as to inform systems design.

8.1 The Activity-Oriented Design Method (AODM)

The *Activity-Oriented Design Method* proposed in this thesis incorporates *four distinct Method tools* designed to support the processes of gathering, analysing (includes systems evaluation) and communicating (modelling) design insights based on Activity Theory. The four methodological tools incorporated in AODM are presented and summarised in Table 14.

Activity-Oriented Design Method (AODM)	
Tools	Description
Eight-Step-Model (See Table 6 in section 5.6)	The <i>Eight-Step-Model</i> operationalises Engeström’s activity triangle model (Figure 5 in section 3.4) by translating the various nodes or components in terms of a situation being examined.
Activity Notation (See Table 9 in section 6.5.1) - Incorporates three-operational-guidelines (See Table 10 in section 6.5.1)	The <i>Activity Notation</i> is enhanced by <i>three-operational guidelines</i> that facilitates: - <ul style="list-style-type: none">• Levelled abstractions during analysis by enabling the decomposition of the main activity system into sub-activity triangles.• Reduction of cognitive complexity when analysing an activity system by generating sub-activity triangles to work with. The sub-activity triangles are united through the shared object of the main activity system.• The analysis of relationships <i>within</i> and <i>between</i> the various components of the main activity system so as to identify contradictions.• The <i>generation of research questions</i> based on sub-activity triangles.
Generating Research Questions (See Table 11 and 12 in section 6.6.1)	The technique of <i>generating research questions</i> operationalises sub-activity triangles resulting from the decomposition process so as to support data gathering and analysis from an Activity Theory perspective.
Mapping Operational Processes (See Figure 12 in section 6.8)	The technique of <i>Mapping Operational Processes</i> supports the cognition of AODM’s execution structure by making operational processes, entities and links explicit, therefore enhancing ease of use.

Table 14: The Activity-Oriented Design Method

A detailed description of the development and application of AODM tools' is given in chapters five, six and seven. The four AODM tools presented above (in Table 13) can be applied iteratively in a six stage process described as follows.

- Stage 1. Interpret the situation being examined in terms of Activity Theory
- Stage 2. Model the situation being examined
- Stage 3. Decompose the situation
- Stage 4. Generate research questions
- Stage 5. Conduct a detailed investigation
- Stage 6. Interpret and communicate findings

Stage 1. Interpret the situation being examined in terms of Activity Theory

AODM begins by attempting to understand human practices in the environment or context of use for the proposed computer system from an Activity Theory point of view. As discussed in chapter five (section 5.1) of this thesis, AODM uses Engeström's model (Figure 5 in section 3.4) to unify the various basic concepts of Activity Theory considered relevant to work analysis and tool design. The initial task when using AODM is to interpret the activity triangle system in terms of the situation being examined. The *Eight-Step-Model* is used here to accomplish this translation process. This entails working through the general open-ended questions that are incorporated within the Eight-Step-Model to meaningfully translate the various components of the activity triangle system. Through this translation process, general information about human practices and the kind of mediators that exist within the situation being examined is gathered.

Stage 2. Model the situation being examined

During the second stage of using AODM, information gathered in *Stage 1* is used to model work practices of the situation being investigated so as to produce an activity triangle system of that situation. This modelling process makes it possible to interpret and verify the correctness of the information gathered about practices in the situation being studied. Modelling also supports the process of

communicating information gathered to other stakeholders within the design team. However, as discovered during the empirical work described in chapter six (see section 6.4), it is difficult to conduct a critical analysis of human practices represented in the activity system generated at this stage because the information gathered is too general. As a result, the activity system produced at this stage can be complex because it incorporates within it several other processes or sub-activities that together make up the main activity system. Hence, a levelled abstraction of this complex activity system is required so as to reveal the various sub-activities and relationships incorporated within the activity system.

Stage 3. Decompose the situation's activity system

At this stage AODM introduces the *Activity Notation* to decompose the complex activity system that was produced in Stage 2. This decomposition helps to reduce complexity by introducing smaller manageable constitutive units or sub-activity systems to work with. These sub-activity systems are linked together through the shared object or objective of the main activity system. The shared object is that of the main activity system produced in Stage 2 and is common to all components.

Stage 4. Generate research questions

Stage 4 involves the *generation of research questions* based on sub-activity systems or components resulting from the decomposition in Stage 3. Each research question is therefore, directly linked to a particular sub-activity system or component within the main activity system. Generating research questions in this way makes explicit the link between research questions generated and the various components of the main activity system. Research questions generated at this stage can then be used to support data gathering and analysis during requirements capture. The questions can also be used during the systems evaluation phase to support the process of validating whether or not the specified user requirements have been met.

Stage 5. Conduct a detailed investigation

A detailed investigation would use the research questions generated in stage 4 during data gathering as in interviews, questionnaires, and observations. At this point, it is worth mentioning that AODM does not stipulate how to conduct interviews or observations when using generated research questions during the study. I considered such an elaborate approach to be too restrictive and not suitable for all purposes. Whilst AODM is focused on providing a well-structured application procedure, the need to be flexible in the method's application mechanism is equally vital.

In addition to aiding the data gathering process, the research questions generated in stage 4 can also be used as pointers to what to look for during data analysis so as to help make sense of data gathered. During data analysis, AODM focuses on identifying possible contradictions in relationships *within* and *between* the various sub-activities that exist within the main activity system. The aim of this kind of analysis is not to find or predict possible solutions for the identified contradictions, but instead to obtain a comprehensive understanding of the means by which these contradictions develop, from a social cultural historical perspective. Having gathered and analysed data during a detailed investigation, the next step is to interpret and communicate findings.

Stage 6. Interpret and communicate findings

During this stage, the information obtained in stage 5 is interpreted and communicated to other stakeholders by re-modelling the activity system of the situation being examined. At this stage, it is also possible to graphically show the mappings between sub-activity systems and research questions generated in Stage 4, and also the identified areas of contradictions. This kind of mapping is illustrated in Figure 12 (see section 6.8). The mappings provide a reversible conceptualisation of the various entities and operational processes that exist when using AODM. Using this approach, it is for example, possible to map identified contradictions onto the sub-activity triangle component in which they exist. The

AODM technique of modelling mappings of entities and operational processes helps the designer to explicitly communicate observed relationships *between* and *within* the various components of the activity system as part of the systems design process. Finally, the technique of mapping operational processes also facilitates ease of method comprehension and use by making the various process and entities incorporated in AODM explicit.

8.1.1 Summary

The above six stages provide a systematic and complete illustration of AODM application structure. Whilst the description of AODM is presented in six consecutive stages, this does not imply that the Method ought to be strictly applied sequentially. The user has total control over the application procedure. For example, whilst some users may benefit from a systematic stage-by-stage application procedure, others may opt for a more flexible approach that enables them to skip or modify certain parts of the method. The flexible approach to applying AODM would be most preferred by users wishing to incorporate AODM with other methods already in use. The key strengths of AODM lie in its theoretically underpinned approach to identifying contradictions or problems in human practices. This strength is enhanced by AODM's capability to positively use identified contradictions to establish new understandings of the examined human practices. Specifically, the Method helps to conceptualise human activity at various levels of granularity for design purposes. From the HCI design point of view, this kind of insight can help to make sense of the multiple relationships that exist *within* and *between* various work processes, levels of operations, and, the kind of tools employed to mediate human activity.

Finally, an innovative design method based on a very complex and dynamic theoretical framework like Activity Theory is bound to meet skepticism from various sources regarding its validity. Therefore, in order to demonstrate confidence in the validity of AODM, the sections that follow discuss how the method was validated. These discussions begin by exploring the concept of validation initially from a

general systems design perspective, thereafter focusing on the HCI design point of view as outlined in section 8.2. Within these discussions, special emphasis is put on issues considered vital when validating a theory informed design method like AODM. The actual validation procedure employed to assess the utility of AODM is presented in section 8.3. This involves the generation of claims about contributions of AODM tools to HCI design whilst providing evidence from the case studies to support the outlined claims.

8.2 The Concept of Validation in Systems Design

There are a lot of diversities in the definition and application of the concept of validation in various research fields. In software engineering, the term validation is used to refer to the process of ensuring that the ‘right system’ is built. In the meanwhile attributes of that ‘right system’ are loosely defined or unspecified. Validation is also often closely related to other techniques used to ensure the quality of a computer system e.g. verification. In short, validation and verification are two very different and complex processes used to assess the quality of a computer system. Whilst validation is used to refer to the less formally specified process of ensuring that the right system is built, scientists with a background in cognitive sciences tend to associate verification with the controlled “process of determining the truth or correctness of a hypothesis” (Reber, 1985).

8.2.1 The Concept of Validation in HCI Design

In HCI design, validation is usually associated with the evaluative process of checking that the design satisfies the high-level requirements agreed with the customer (Dix et al., 1998.p.184). Therefore the traditional approach to validation within the HCI design context is to begin by establishing a validation plan that satisfies already established design requirements. The validation plan outlines the validation objectives. Validation objectives stipulate the reasons for carrying out the validation exercise in relation to the outlined design requirements. Hence, validation in the context of HCI design, can involve substantial human factor issues. As a result of this, there are bound to be some emotional, cultural and contextual issues

associated with the acceptance of the validity of a system. For example, the HCI design approach to validation would require that the parties involved in the design team reach a consensus with regards to the kind of properties or attributes to be tested. However, this kind of consensus typically evolves over a period of time. Therefore an increase in evidence increases the level of confidence and consensus. In addition, different stakeholders within a design team will have differing ideas about what is required to prove the validity of a design method or the effectiveness of the resulting system. In such situations, it can be difficult to produce agreeable and realistic set of validation objectives that reflects the defined design requirements. This is so because such objectives ought to combine the participants' operational experience, project aims, and theoretical orientations. The objectives will also be shaped by the complexity of the application of the method as well as the resources available for the design activity. As a result of these issues, any approach employed to validate a theory based design method must take overall concerns into account in order to give credibility to any results finally produced.

Since AODM is a theory informed design method, it is worth reviewing some of the issues surrounding the task of validating such methods prior to describing the approach employed to validate AODM.

8.2.2 Validating a Theory Informed Design Method in HCI

The Activity-Oriented Design Method proposed in this thesis is a theory informed method for guiding HCI design. The introduction of a theory informed design method raises a lot of concerns with regards to its validity in terms of the level of contribution made within the systems design process. In most cases, these concerns are driven by the recognition that common practices for validating theory based design methods are not easily accepted on scientific grounds. In addition, lack of sufficient information in the literature as to the uptake of theory informed methods in the actual design practice (Rogers, 2001) makes it difficult to verify the validity of such methods within systems design. Hence validation in this regard becomes essential to demonstrate the quality and technology transferability of the method into

the systems design process. In this respect, validation provides evidence to confirm that the method does what it purports to do.

However, validating a theory informed design method can prove to be a very complex task due to the fact that the contribution of such methods is usually viewed in the context of its role within the wider systems development process (Rogers, 2001). Meanwhile, the wider systems development process includes and extends to judgements on the usability and usefulness of the resulting product developed using the method. Successful validation of a theory informed design method cannot guarantee, in general that the subsequent system will be useful. Neither could validation prove that a method is suitable for a particular design effort because such decisions are *social* in nature. As a result of this social inclination, the individuals involved in a design activity are the only ones that can determine whether or not a method is suitable for the context and purpose of use. At best, validation can only certify that a given method is at least as competent as specified by the developer or as indicated by results of the tests carried out. Therefore, the validity of a theory informed design Method cannot be proved per se; it can only be determined within the unbounded principles of multi-disciplinary HCI research. Given this stance, the complexity in validating a theory informed design Method results from the fact that it is heavily associated with highly psychological principles that focus on human factor issues. Hopkin (1993) in his discussions of “verification and validation: concepts, issues and applications,” warned against validation approaches that focus on human factor issues to draw conclusions about quality. He argues that an essential flaw lies in the posed risk of ignoring formal approaches during validation. This is nicely illustrated in the following statement: “The paradox is the potential production of conclusions and recommendations about verification and validation which themselves are unverified and unvalidated” (Hopkin, 1993, page 9).

Having reviewed and considered the various issues surrounding the validation of theory informed methods in HCI, I will now discuss how I validated the utility of AODM.

8.3 Validating the Activity-Oriented Design Method

Foregoing discussions have extensively evaluated the concept of validation in HCI and systems design in general. In doing so, emerging issues have been exemplified and addressed within that context so as to acquire informed insights to draw upon when validating AODM. In particular, section 8.2.2, critically reviewed selected HCI approaches to validating theory informed design methods, therefore highlighting possible problems and benefits. Given the outlined considerations, establishing a straightforward and comprehensive approach to validate AODM proved to be a very challenging and time-consuming endeavour. Nevertheless, this section is focused on outlining the validation approach employed to assess the validity of AODM in HCI design. These discussions begin by setting out the objectives for validating AODM. Thereafter, the validation procedure for AODM is illustrated based on six claims that can be made about contributions of AODM to HCI design. Empirical evidence from the two organisations used in the study is presented in support of these claims. Finally, the chapter concludes by reflecting on issues raised in discussions pertaining to the validity and contributions of AODM to HCI practice.

8.3.1 Objective for validating AODM

In contrast to accepted evaluation norms in HCI design, the objective for validating AODM was not to prove the correctness of the method or reveal errors in its application so as to attempt to provide solutions for these. Instead, validation was carried out to express confidence in the overall quality and utility of AODM in supporting the focused HCI design tasks of gathering and analysing data, thereafter communicating acquired insights for design purposes. Having said this, it is also worth noting that successful validation of a design method does not guarantee that the resulting computer system would be right for the purpose to which it is finally put to use.

8.3.2 Procedure for validating AODM

In order to validate the usability of AODM, I adapted and used Long's (1989) framework for describing HCI activities, so as to structure and characterise AODM development and application procedure. Long (1989) was concerned with the issue of the relationship between 'basic science' (theory) and its application (practice). According to Long, the relationship between theory ('scientific world') and practice ('real world') can be understood by analysing "intermediary representations, and associated activities that transform one into another" (Long, 1989). He argued that knowledge incorporated in the 'scientific world' helps to understand the way the 'real world' works. Therefore the relationship between the 'scientific world' and the 'real world' can be understood in terms of *intermediary representations*, since these help to translate the 'real world' into the 'scientific world'. Long, further illustrated his ideas by designing a model for conceptualising 'ergonomic' activities within HCI. In so doing, he developed an analytical structure for explicating relationships that exist between theory and practice as part of HCI design. A modified version of Long's (1989) model that was used to structure and characterise AODM development and application activities for validation purposes is presented in Figure 16. Long's (1986; 1989) model incorporates three 'paradigms' for characterising HCI activities, these are namely: *science*, *engineering*, and *systems development*. The 'science paradigm' (shown as 'Scientific World' and 'Unifying Representation' in Figure 16) incorporates theories and models necessary for understanding the 'real world'. The 'engineering paradigm' (shown as 'Application Method Representation' in Figure 16) reflects knowledge about applying theory or scientific knowledge to study the 'real world'. Finally, the 'system paradigm' is concerned with understanding factual knowledge about the 'Real World', in terms of contextual practices, individual and social needs, transformations that occur, also the physical and social environments in which a computer system is to be deployed, etc.

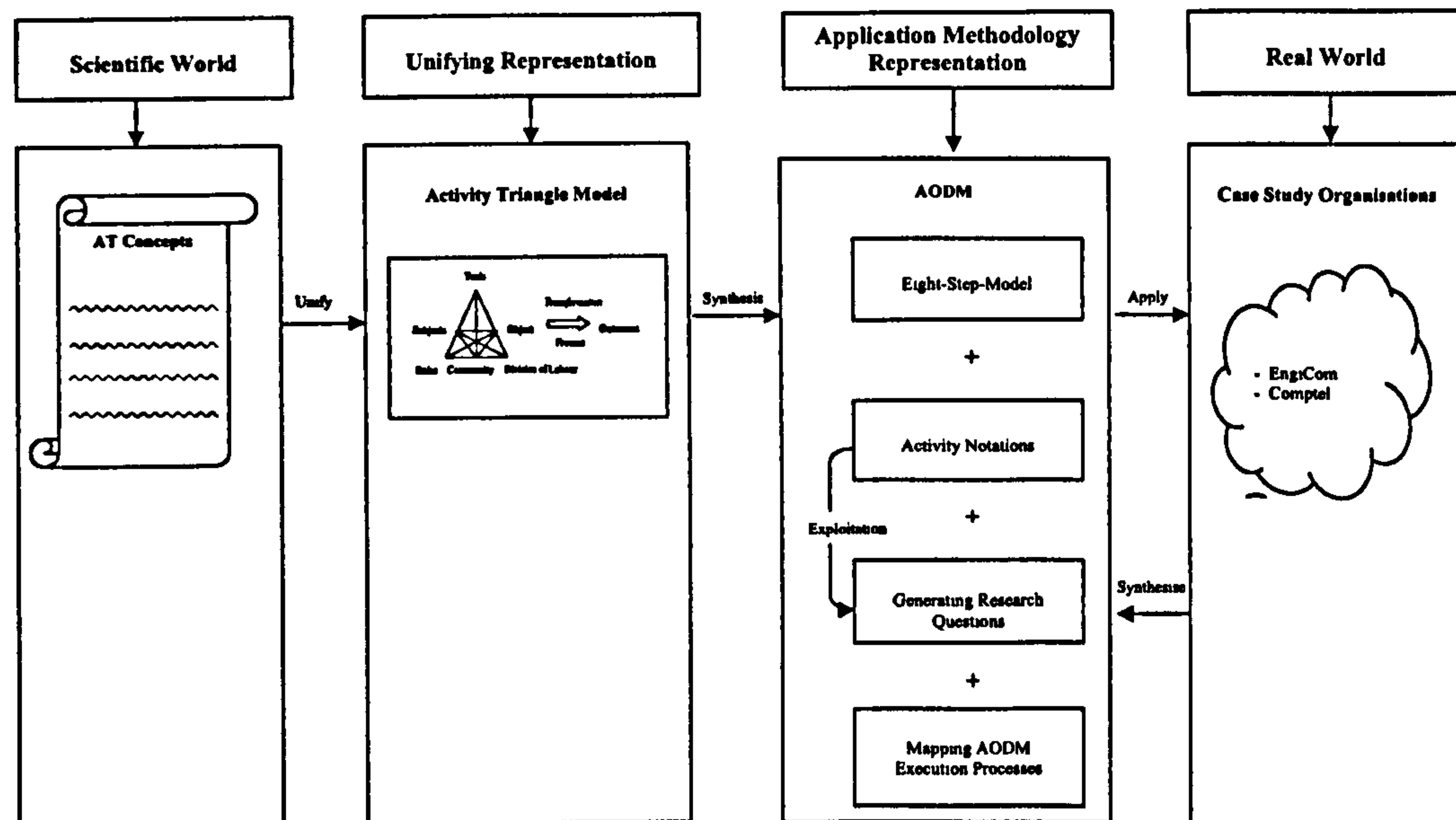


Figure 16: Outline of approach for Validating AODM (model adapted from Long, 1989)

Figure 16 shows four entities presented in vertical rectangular blocks. The *first* entity presented under the title 'Scientific World' represents the *science paradigm*, which outlines various theoretical concepts incorporated in Activity Theory. The *second* entity appearing under the title marked 'Unifying Representation' also represents the *science paradigm*, and presents the Activity Triangle Model (Engeström, 1987) as a uniting model for representing concepts of Activity Theory. The *third* entity appearing under the title 'Application Method Representation' depicts AODM as an *engineering paradigm* for operationalising Activity Theory within HCI. Within this entity, the four design tools incorporated within AODM are outlined. Finally, the *fourth* entity with a title labelled 'Real World' represents the *systems development paradigm*, which incorporates the two case study organisations (EngiCom and Comptel) used during the thesis empirical investigations. The characterisation of AODM development and application activities portrayed in Figure 16 also outline the method's transition from a 'Scientific World' of Activity Theory concepts to 'Real World' practices of the two case study organisations.

Long's model was considered appropriate for validating AODM because it helps to:

- Depict relationships that exist between concepts of Activity Theory and the activity triangle model used to representationally *unify* theoretical concepts.
- Show how the activity triangle model helped to *synthesise* AODM tools.
- Representationally show how to *apply* AODM tools to the analysis of practices in the 'real world'; in this case, work practices in the two case study organisations discussed in chapters five, six and seven.

In addition, Long's framework helps to show the inter-relatedness of the key entities involved in operationalising Activity Theory within HCI design whilst structuring the procedure for evaluating intermediary representation. This way, it is possible to understand how Activity Theory as a 'scientific world' of ideas is unified and represented in the activity triangle model, thereafter, to validate its application within HCI design by using AODM as an 'engineering representation' that helps us to understand 'real world' practices of the two case study organisations (discussed in chapters five, six and seven). A key advantage of this validation approach is that, by conceptualising key entities and intermediary relationships, it is possible to establish the kind of support required to enhance the usability and usefulness of AODM in HCI design. Intermediary relationships between entities are shown in Figure 16 using directional pointer arrows labelled '*Unify*', '*Synthesis*', and, '*Apply*'. Since AODM is presented both as an analytical and practical tool for operationalising Activity Theory in HCI design, its validity was therefore determined by generating claims about the usability and usefulness of the incorporated methodological tools in supporting the operational aspects of the intermediary relationships and entities outlined in Figure 16. From this point of view, claims about the usability and usefulness of AODM tools in supporting HCI design offer one means of validating AODM. I will now present the various claims and supporting evidence from the case studies.

The first claim (Claim One) relates to the ‘*Unify*’ intermediary relationship between the ‘Scientific World of Activity Theory’ and the ‘Activity Triangle Model’ as a unifying representation of the ‘scientific world of theory’.

Claim One

AODM provides a structured and grounded approach for operationalising Engeström’s (1987) activity triangle model.

Evidence:

- a) The first evidence in support of ‘claim one’ is demonstrated in the Eight-Step-Model’s support for systematic translation of the various nodes of the activity triangle model. This translation process is facilitated by the ‘open-ended questions’ incorporated within the Eight-Step-Model. The translation process enables the designer or user to generate meaningful data, thereby facilitating the production of a meaningful and theoretically grounded conceptualisation of human practices being studied. For example, in chapter six (see section 6.4) ‘open-ended questions’ incorporated in the Eight-Step-Model were successfully used to translate various nodes of the traditional activity system (Figure 5 in section 3.2.3) in terms of work practices at Comptel. This translation process resulted in the gathering or accumulation of meaningful information about work practices in this organisation that was finally meaningfully modelled as depicted in Figure 10 (see section 6.4).
- b) The second evidence in support of ‘claim one’ can be found in the Activity Notation’s support for the establishment of interconnections between various nodes or components of an activity system. These interconnections represent relationships that exist *within* and *between* components of the system under investigation. For example in section 6.5.1 (chapter six) the operational structure of the Activity Notation (Table 9) is exemplified by using three-operational-guidelines (Table 10) to generate notational combinations that represent sub-activity triangles of the activity system. These sub-activity

triangles later form the basis for generating research questions used to gather detailed data that was specific to work practices at Comptel as shown in Table 11 and 12 (section 6.6.1). The same approach was successfully employed when gathering detailed data about EngiCom team based work practices as illustrated in section 7.2.

The second claim (Claim Two) relates to the ‘Synthesis’ intermediary relationships between the Activity Triangle Model as a unifying representation of the various concepts of Activity Theory, and also the AODM tools as a representation of the ‘application method’. It relates to the construction and modification of AODM tools from the Activity Triangle representation and also their subsequent application to the ‘real world’ case studies.

Claim Two

The AODM approach can easily be integrated with other design methods.

Evidence:

- a) AODM application procedure is quite flexible. AODM does not stipulate what parts of Activity Theory are relevant to a particular design task. Instead, this method leads the designer to probe or investigate further about the suitability of using Activity Theory into their design effort. Therefore, AODM can easily be adapted and integrated with other design methods already in use. This claim is supported by the systematic development and flexible application procedure adapted in AODM. AODM offers the designer the flexibility to apply it either in a general way or in a much more specific manner so as to acquire meaningful data. When applied in a general way, the designer does not need to translate the activity system (Figure 5 in section 3.2.3). Instead, the Activity Notation can be used to decompose the traditional activity system (Figure 5 in section 3.2.3) and to generate general research questions (see example in Table 11 of section 6.6.1). The approach to using AODM in a general way yields less meaningful data, but can be a

useful process to go through for those designers wishing to try out the method whilst deciding how to integrate it with other approaches. Designers can therefore use the Eight-Step-Model to translate the activity triangle model (Figure 5) according to the situation being analysed so as to obtain meaningful data. See for example Figures 10 in section 6.4, which shows a translated activity system modelling work practices at Comptel. This translation process introduces flexibility in the method application procedure therefore making it easy to adapt AODM and use it meaningfully in various contexts.

The next four claims (Claims Three, Four, Five and Six) are associated with the ‘*Apply*’ intermediary relationships between the various AODM tools and the ‘Real World’ (case studies).

Claim Three

AODM can be successfully applied to the analysis of real world settings.

Evidence:

- a) Support for this claim is evident in the fact that AODM tools can be tailored and applied to the analysis of real world settings. For example, both sections 6.1 and 7.1 provide an example-based illustration of how both the Eight-Step-Model and Activity Notations were successfully applied to the study of work practices at Comptel and EngiCom respectively. In addition to this, both chapters six and seven demonstrate how the technique of generating research questions can be tailored to the analysis of specific real world settings. For example, research questions specific to Comptel (see Table 12 in section 6.6.1) and EngiCom (see Table 13 in section 7.2.3) were generated and successfully applied to the analysis of work practices in these two organisations as indicated. The empirical application of the technique for generating research questions in these two case studies proves that method

tools incorporated in AODM can be successfully used to study real world settings.

Claim Four

AODM produces data that can be meaningfully interpreted and usefully incorporated in systems design.

Evidence:

- a) Support for claim four is perceived and illustrated from two perspectives. The first one is the ‘meaningfully interpreted’ aspect of AODM, with the second on being the ‘usefully incorporated in the systems design process’ aspect of the claim.

The ‘meaningfully interpreted’ aspect of the claim mainly relates to AODM’s techniques for ‘generating research questions’ that can be used to gather data, which is meaningful to the subjects involved in the activity being analysed. The meaningfulness in this regard is reflected in the kind of language that the designer or researcher uses to describe activity elements for example ‘Plan-Do-Review’ to refer to ‘tools’ (see example of a question based on this, in Table 13 in section 7.2.3) when investigating team based work practices at EngiCom.

The ‘usefully incorporated’ aspect of claim three is supported by AODM’s facilitation of a traceable mapping between generated research questions and sub-activity triangle components. E.g. bar charts vs knowledge sharing. The mapping is evident in the fact that generated research question are based on triangle components of the activity system. See for example, the first question presented in Table 13 (section 7.2.3) “*How does the Plan-Do-Review (tools) technique help team members (subjects) to learn from each other’s experiences (object)?*” This back and forth mapping between generated research questions and triangle components indicates that an

analytical structure is already in place. The pre-existence of a data analytical structure makes it easier for the designer to usefully interpret and incorporate acquired insights into the communicative design process of modelling work practices. This is demonstrated in Figure 14 (see section 7.2), which shows both the traditional component labels of the activity system and also the meaningful interpretation of those labels specific to EngiCom teams. By using this kind of translation and cross mapping when modelling human practices, the designer can meaningfully and usefully communicate acquired insights to other stakeholders on the design team. Other stakeholders on the design team do not necessarily need to have participated or been closely involved in the actual study to be able make sense of what is being communicated in the model.

Claim Five

AODM can be easily used by designers and other users with little knowledge of Activity Theory.

Evidence:

a) Ease-of-use

AODM is targeted towards systems designers and other users who may already have some basic understanding of Activity Theory but are unsure about how to put these concepts into practice. However, this proposition should not be considered as a prerequisite for using AODM, even though it may be advantageous if the user knew a little bit about Activity Theory. Usability of AODM is not dependent on a deep understanding of the underlying theory because AODM is generally transparent about basic Activity Theory concepts. This transparency is evident in the representational and syntactical structure of the tools incorporated within AODM. For example, the syntax used in presenting the structure of the Activity Notation (Table 9 in section 6.5.1) is based on activity triangle components names utilised in Engeström's activity system. In this regard,

AODM tools incorporate systematic explanations of the syntax used as notational affordances used to support the user's cognitive process of reasoning about AODM's operationalisation of Activity Theory concepts. This is evident in the Activity Notation's three-operational-guidelines. In addition to this, the execution mechanism for the Activity Notation is made explicit through use of the 'three-operational-guidelines' so as to enable the user to understand the semantics of the notational structure employed. Overall, the notations used in AODM tools are generally semi-formal (they include other symbols). The use of semi-formal notations helps to achieve a balance between understanding the execution logic of the method and adhering to the semantics of the underlying theoretical concepts.

Another contributing factor to ease-of-use is reflected in AODM's ability to support levelled abstractions of the activity or task being analysed. Levelled abstractions are demonstrated through AODM's decompositional process, which supports the breaking down of a complex (main) activity system into smaller manageable units. Decomposition is facilitated through use of the Activity Notation to reduce complexity. In addition, AODM incorporates explicit representational support for relationships that exist *within* and *between* various processes and components of an activity system. This representational support is evident in the technique of modelling mappings between processes and components as shown in Figure 12 (section 6.8). Figure 12 representationally shows links between sub-activity systems, research questions generated, and, identified areas of contradiction. This kind of representational mappings enhances ease-of-use by making AODM's operational processes, entities and links explicit.

b) Feedback

Finally, the technique of mapping AODM operational processes also supports communicative aspects during design. By making areas of contradictions explicit through modelling mappings (see Figure 12), this approach makes it

possible for AODM users to continuously reflect on design practices and incorporate feedback within the design process. This is achieved through applying AODM iteratively therefore making it possible to review both the analytical findings from the context of study and also the method application procedure. From this perspective, AODM facilitates traceability and responsive accountability for emerging issues during design.

Claim Six

AODM presents a systematic and well-structured illustration of the data acquisition and analysis procedure.

Evidence:

- a) AODM provides systematic and well-structured formal heuristics or guidelines for encapsulating ‘craft’ or practical skills for using the method. For example, the open-ended questions incorporated within the Eight-Step-Model and also the technique of generating research questions provide step-by-step guidelines on how to use the method to support data gathering. This is evident in chapter six (see section 6.1) which discusses how the Eight-Step-Model’s open-ended questions were successfully used to gather data from Comptel. In addition to this, AODM provides guidelines on how to analyse data gathered by providing informal heuristics or tips on how to identify key relationships to focus on when trying to identify contradictions. Empirical evidence for this claim can be found in section 6.7, which discusses how AODM leads to the identification of two key relationships to focus on when analysing data gathered from Comptel.

8.4 Reflections and Conclusions

There has been a long standing debate around the transferability of novel theory informed research techniques and methods into the practical aspects of systems design (Bannon, 1997; Blandford, Buckingham Shum and Young, 1998; Buckingham Shum and Hammond, 1994). A common theme that emerges within

these discussions is the constant need to provide proof as to the practical contributions of theoretical insights into design practice. In the meanwhile, the kind of proof presented in support of the transferability of a theory informed design method can be determined by many issues including the interpretation of the term 'design'. In situations whereby 'design' is associated with the engineering process of producing a computer system, validation would entail the demonstration of a direct link between the method and interface features of the system built. On the other hand, in situations whereby design is broadly interpreted to include various cognitive and physical design processes, evidence can be based on the accuracy of the method's representation, interpretation and operationalisation of underlying theoretical concepts.

Validation of AODM relied on empirical evidence drawn from the two case studies carried out as part of the thesis' research. The use of an empirically driven approach to validate the quality of a theory informed design method like AODM provides a suitable grounding for certifying its utility in real life contexts. One of the essential advantages of using an empirical approach to validate a theory informed method emerges from the fact that output from such validation leads to a sequence of validation statements rather than a single declaration. However, empirically demonstrating the validity of a theory informed design method can also prove to be a very complex endeavour. The crux is that the validity or (in)validity of such a method is determined by the extent to which the method relates to concepts of the underlying theoretical framework and also the context of use, whilst demonstrating its technological transferability. In terms of output, empirical validity is not a binary trait, but rather a degree to which parties involved agree or disagree on the validity of a method. Results obtained from validating AODM could not be easily reduced or converted to numeric degrees so as to express the certainty of satisfaction in quantifiable terms. Therefore, the validity of AODM was determined from the point of view of its perceived strengths and weakness in its ability to guide the design processes of gathering, analysing and communicating (modelling) acquired insights. The qualitative validation results outline herewith represent an abstract level of

satisfaction as to the resilience of AODM in relation to its ability to support both practical and analytical aspects of systems design.

Chapter Nine

9. Conclusions and Future Work

*“There are things known, and there are things unknown.
And in between are the doors.”*

Jim Morrison – Reference unknown.

This chapter summarises the work reported in this thesis by revisiting the research problem and question outlined in chapter one (see section 1.2) so as to reflect on contributions made. Within these discussions the extent to which contributions made address the key research question is reviewed. In addition to this, currently perceived limitations of the contributions made are outlined. Finally, suggestions about possible areas of future research directions are presented.

9.1 Thesis summary

This thesis has explored the practical means by which concepts of Activity Theory can be incorporated in systems design practices of the HCI field. The rationale behind this effort has been the recognised need to make computer systems functionally useful to the user. Whilst it is safe to say that the design of computer systems has reached an acceptable level of *usability* in terms of the functional aspects and look of interface features, there is a lot to be desired with regards to the *usefulness* of these tools in enabling the user to achieve desired goals. Developments in the usability aspect of computer systems are evident in the prolific increase in the use of these tools in human beings' everyday activities. However, there also have been some noticeable increases in the failure of computer systems to meaningfully support users to achieve desired work goals. This has been attributed to amongst other things, the objective use of computer systems by human beings, which has meant that issues relating to the 'fitness for purpose' or 'usefulness' of these tools

have now taken precedence. At the heart of this problem are issues underpinned by the contextual use of computer systems, which in most cases influence users' judgement on the usefulness of a computer system within a particular activity. Furthermore, human practices are not static; they constantly evolve, which implies that design requirements for computer systems used to mediate human activities equally constantly change. Whilst HCI researchers and practitioners acknowledge the existence of these design requirements and user concerns, the impediment has been the lack of a unifying theory for conceptualising these issues (Bannon and Bødker, 1991; Kuutti, 1996; Nardi, 1996). Consequently, many HCI researchers and practitioners have identified Activity Theory as a possible framework that fulfils this *conceptual vacuum* (Bannon, 1990b; Kuutti, 1996; Nardi, 1996).

However, as established in the literature review presented in chapter four of this thesis, there is no standard method for applying concepts of Activity Theory to HCI design. The lack of a standard practical method for applying Activity Theory to HCI research and practice signifies the existence of a *pragmatic vacuum* in the incorporation of Activity Theory insights within HCI (Bannon, 1997; Rogers, 2001). Given this stance, the key question that this thesis set out to research is:

How can Activity Theory be applied to HCI research and practice so as to inform systems design?

In order to investigate this question, I took up the challenge of filling the identified 'pragmatic vacuum' by conceptualising and constructing the "Activity-Oriented Design Method" (AODM) for use in HCI research and practice. AODM was developed iteratively in the context of analysing work practices in the two case study organisations described in chapters five, six and seven. In so doing, the thesis drew insights from both the Activity Theory and HCI literature so as to develop a method that theoretically adheres to concepts in the Activity Theory framework, and at the same time, a method that is operationally relevant to HCI research and practice.

9.2 Thesis contributions

This thesis contributes the *Activity-Oriented Design Method* (AODM) to the HCI field. Whilst the principle focus of the research conducted during the empirical studies described in chapters five, six and seven was to develop a practical method for using Activity Theory within HCI, the investigation also succeeded in producing an Activity Theory conceptualisation of work practices in the two organisations examined. The construction of a method that supports both analytical and practical aspects of systems design denotes that contributions of this thesis are two fold: *first*, this research has delivered an Activity Theory based method for analysing ‘real world’ work contexts; and *second*, the development of a practical method for applying concepts of Activity Theory within HCI research and practice. Analytically, the thesis’ contribution has demonstrated how Activity Theory using AODM can be used to conceptualise human practices in ‘real world’ work contexts. Practically, the thesis has shown how an Activity Theory based method – AODM can be used to guide the design processes of gathering, analysing, and communicating insights about targeted users of a computer system. This includes information about the context of deployment for the proposed system.

The two strands of AODM’s contribution to HCI research and practice are summarised as follows.

- 1) AODM supports the following practical design processes:
 - *Data gathering* - through the introduction of a technique for *generating research questions* based on sub-triangle representations. Generated research questions can be used for example, in interviews, observations and questionnaires (see examples in Table 10 of section 6.6.1).

- *Operationalising Engeström's activity triangle model* (Figure 5 in section 3.2.3) by using the *Eight-Step-Model* (Table 6 in section 5.6) to translate the various triangle components in terms of the situation being examined therefore facilitating meaningful conceptualisation and modelling of the situation under investigation.
 - *Modelling data gathered* - by using the *Eight-Step-Model* to meaningfully interpret data gathered according to components of the traditional activity triangle model (Figure 5 in section 3.2.3). This feature also supports *communicative aspects* of the design process by enabling designers or researchers to representationally share acquired insights about user practices with other stakeholders on the design team.
 - Decomposing a complex activity system through use of the *Activity Notations* (Table 9 in section 6.5.1) enhanced by *three-operational-guidelines* (Table 10 in section 6.5.1) to facilitate levelled abstractions when conducting an investigation.
- 2) AODM supports the analytical design processes of:
- Meaningfully translating activity triangle components in terms of the situation being studied. This is achieved by using the *Eight-Step-Model* (see example in section 7.2 and 7.2.1).
 - Meaningfully interpreting data gathered by aiding the process of identifying key triangle relationships to focus on during data analysis so as to identify contradictions (see example in section 7.2.1).
 - Conceptualising the method's operational structure facilitated by the *technique for mapping operational processes* (see Figure 12 in section 6.8). This feature of AODM enables the designer or any other user to

comprehend the method's application procedure and assess the suitability of using the method within their design task.

9.3 Why AODM

The “Activity-Oriented Design Method” (AODM) proposed in this thesis brings the richness of Activity Theory to HCI research and practice by supporting the design processes of gathering, analysing and communicating design requirements. To accomplish this, AODM utilises Engeström's model of human practices – the activity triangle model (Figure 5 in section 3.2.3) as a unifying representation for Activity Theory concepts. In order to provide the outlined operational support, AODM consists of four methodological tools described in detail in chapter eight (see Table 14 in section 8.1). The four methodological tools incorporated in the AODM are summarised as follows (see also chapter one section 1.3):

- *Eight-Step-Model* (Table 6 in section 5.6) developed to operationalise Engeström's model of human activity – the activity triangle system in terms of the situation being examined.
- *Activity Notation* (Table 9 in section 6.5.1) developed to aid system decomposition by breaking down a complex activity system into smaller manageable units or sub-systems.
 - *Three-operational-guidelines* (Table 10 in section 6.5.1), enhances the operational aspects of the Activity Notation by outlining its application structure.
- The development of the idea of *generating research questions* (see examples in Tables 11 and 12 in section 6.6.1) based on the various components of the main activity system.

- The development of a technique of representationally *mapping operational processes* (see Figure 12 in section 6.8), also *relationships* between sub-activity system components and identified contradictions.

9.4 Strengths and Limitations of AODM

The use of AODM to investigate both formal and informal aspects of work practices in the two case studies has demonstrated that the method is suitable for studying both structured and unstructured work contexts. However, whilst the method's application in structured work contexts may require less work, its use in unstructured work contexts may require more work. This is so because whilst the operational structure of formal work contexts, for example, work practices in an organisation tend to be explicit, unstructured work context, for example, work practices in a voluntary group can be inexplicit. There is therefore a need for high adaptation through the iterative application of AODM tools so as to reveal the operational structure of informal work contexts. This is so because unstructured work settings have social characteristics that are difficult to identify. AODM can still work in both contexts although its use in unstructured work settings may prove more challenging, for example, when identifying contradictions in work practices.

In addition, AODM is most suitable for analysing human practices whereby several individuals are collaborating in carrying out mediated activity. This requirement results from the underlying theoretical framework's focus on social and cultural aspects of what is being analysed. Having said this, AODM can also be successfully applied in situations whereby the designer's aim is to understand the means by which a single individual interacts with a tool when carrying out activity. In such situations, AODM can enable the designer to address wider issues related to the individual's interactions with objects of the environment of practice using a computer system. These wider issues includes the establishment of the objective for carrying out the activity, rules and regulations governing how activity should be carried out in that context, etc. From this end, AODM is not intended to replace

established HCI methods for analysing systems usability but instead, it is meant to compliment them by putting them in a wider social and cultural context.

Another aspect of AODM that may be perceived as a limitation to its use in HCI design is its lack of support for predicting user behaviour or possible future work practices. Even though AODM can help to identify contradictions in the situation being examined, for example, by highlighting key relationships to focus on during the analysis (see section 6.7), it is not suitable for making predictions about human behaviour. A designer cannot therefore successfully use AODM to predict or make assumptions about how users are going to behave when interacting with a computer system. Neither can a designer use AODM to generate solutions to HCI design problems or predict solutions for the identified contradictions in studied work practices. The reason behind this draws from Activity Theory's emphasis on understanding human practices historically from the user's view point, but not to predict future behaviour.

One of the key strength of AODM emerge from the fact that it builds on earlier efforts by other researchers (Kaptelinin et al. 2000) to demonstrate the link between theory and practice. AODM demonstrates this link by providing a traceable mapping between activity triangle components and generated research questions. The significance of this link draws from the fact that the activity triangle model is used in this thesis as a unifying representation for basic principles of Activity Theory (see second paragraph in section 5.1). Therefore, the activity triangle model and its components represent the theory itself whilst generated research questions indicate the practical operationalisation of these theoretical concepts. When compared to existing Activity Theory informed method, for example, the ¹Activity Checklist introduced by Kaptelinin and others (2000), AODM offers a step forward by making the link or relationship between activity triangle components and generated research

¹ The thesis discusses the *Activity Checklist* (Kaptelinin et al., 2000, in section 2.2.11)

questions explicit. The Activity Checklist does not provide a direct and traceable mapping between research questions and theoretical concepts presented.

An additional strength of AODM is evident through the approach to providing the user with a recommended approach for selecting and using the generated research questions when conducting activity analysis. In addition to this, AODM also helps the user to define the scope of the activity to be analysed by introducing a research question that prompts the user to define the activity of interest when using the Eight-Step-Model (see section 5.6). This kind of methodological support is not provided in the Activity Checklist introduced by Kaptelinin et al., (2000).

9.5 Future Work

The work leading to this thesis has generated many interesting and promising ideas. Some of these promising ideas are worth exploring further, other equally promising ideas have been dropped during the course of the research due to various reasons. In the following section, currently envisioned possible areas of extension are discussed.

Validating the usability of AODM with users other than the author

In words of Larry Constantine (2001):

“Ultimately, the true pace of change is not dictated by the evolution of science or technology or of ideas, but by the capacities of humans and human social systems to accommodate change. A product, a service, a practice, or a perspective – however new and innovative – can have no impact without acceptance; no significance without change in people and their institutions”(Constantine, 2001).

The complexity of the underlying theoretical framework from which AODM was developed meant that a considerable amount of time was spent on interpreting Activity Theory concepts, also the investigation and construction of appropriate techniques for operationalisation these concepts for use in HCI design. Thereafter, publishing results through the production of this PhD thesis, papers in a refereed

journal and international conferences. These practical obligations highlighted the need to test the usability of AODM with different users groups other than the author. Hence, further work is required to verify the usability of AODM by various users groups other than the author, for example, designers or users with little or no knowledge of Activity Theory. AODM could also be tested with users with expert knowledge of Activity Theory.

In addition to this, although the validity of AODM was extensively demonstrated using empirical studies that formed the basis for its development, further work is required to validate its usability in contexts other than the ones in which the method was developed. Such kind of validation would help to verify the scope and utility of AODM in various contexts. Specifically, future work in this regard could explore the practicalities of using AODM to understand adhoc (unplanned) collaborative work or learning practices from a developmental perspective.

Producing AODM user manual

Further expansions of this work could also be directed towards the production of a user manual incorporating tutorial notes documenting the application of AODM in various contexts. The user manual could incorporate an illustration of successes and failures in AODM use case situations. In line with this research idea, both a paper-based and online manual could be produced. The online manual could be implemented as part of a large computer based system used to enhance and automate certain functions of AODM e.g. the ‘generation of research questions’ (see also the next paragraph on ‘Automating AODM tools’).

Automating AODM tools

Finally, even though AODM provides socio-cultural and contextually sensitive techniques for gathering, analysing and communicating systems requirements data, the method does not provide software based tools to support its application.

Therefore, possible extensions of this work could also include the implementation of software-based tools to automate certain operational functions of AODM. For example, software-based tools could be implemented to support the process of modelling activity systems in terms of triangle representations, the technique of mapping operational processes, also to support the analytical process of identifying contradictions in work practices.

Two possible systems could be built. The first systems could be implemented to automate some of the AODM operational functions as indicated earlier. This system would be targeted towards designers or researchers wishing to use AODM as a way of enriching their work practices or studies using Activity Theory. The second system could be developed mainly to facilitate the evaluation processes of assessing the usability of AODM tools in systems design.

9.6 Conclusion

This research had set out to investigate the practical means by which Activity Theory can be used to inform HCI research and practice. Central to this mission was the need to extend on already achieved developments in the usability of computer systems by introducing a novel approach to addressing issues relating to the usefulness of these tools. In so doing, a systems design method based on the Activity Theory framework – the AODM, was conceptualised and constructed for use in HCI research and practice. Whilst the role of Activity Theory in HCI has been recognised as that of filling a conceptual vacuum (Nardi, 1996), this thesis proposes that AODM fulfils a pragmatic vacuum with regards to the operationalisation of Activity Theory in HCI.

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Appendix A

Comptel Case Study

Appendix A - 1

Considerations for Data Collection Method

November, 1999

The main questions to address include; what do I want to find out, how will I find out and why do I want to find out? This initial study of work practices at Comptel will be attempting to obtain insight into the work activity by analysing its evolution and development. This analysis will also include investigations into the role of mediators in work practices together with other environmental factors that may influence in one way or another the means by which this activity happens. What are the objectives of carrying out activity and sub-actions (activities)?

1) *What sort of data do I want to collect?*

Data to be collected will mainly be qualitative and formative in nature so as to obtain insight and understanding of what is going on and how it is done prior to the introduction of a computer system.

2) *Why do I want to collect this type of data?*

Other than the objective of understanding work activity, this data can be used for comparison purposes during the evaluation stage in terms of 'before' and 'after' introduction of computer tool in activity.

3) *How do I want to collect this data?*

Data will be collected by means of audio recording meetings and discussions. Making notes while observing team members at work in terms of collaboration patterns and mediating tools (phone, email, etc). Static image capturing using digital or ordinary camera to obtain photographs showing team members at work. Interviewing of team members as they work and interact. A list of pre-prepared open-ended questions will be used to guide the interview process.

Appendix A - 2

Field Notes

These field notes reflect my own personal translations of data gathered about work activity at Comptel in general. The data presented within these notes was gathered using various techniques that including:

- conducting interviews with workers
- open-ended questionnaires
- carrying out observational studies of work activity in action
- reviewing company documentation, CD-ROMs, also company internet and intranet system.

The various types of data gathered is presented as follows:

Initial briefing by the site manager

Customer Support Hotline at Comptel

Customer Support Hotline is a section of Comptel operating under the Automation and Drives division which provides telephone based assistance or advise to buyers of Comptel' various products and services covering the European and African regions. Three telephone based approaches are used to render customer support.

- 1 - Basic Hotline
- 2 - Premium Hotline {liable for costs, only possible with Comptel Card}
- 3 - Bulletin Board System {Operates a mailbox facility for providing the same information as Customer Support Hotline which can be downloaded onto a PC}

The Customer Support team manning the call centre consist of 70 members who are qualified technical engineers and understand the operation mechanisms of Comptel's products and services on which they offer help to customers. Of the three telephone-based help approaches outlined above, the basic hotline receives about 500 products enquiries a day. A list of frequently asked questions (FAQ) is then produced from these enquiries. Presumably this information goes in a knowledge base system which is constantly updated. The unit operates a job rotation system that helps members to keep up to-date with the different operations / activities of the unit. A specialised training programme for staff enhances this job rotation. This also acts a means for controlling and monitoring the quality of the service provided by the centre in order to ensure that it is up to the required standards.

Comptel Knowledge Manager

This is a knowledge base system or a database which stores 'good practice' type information drawn from previous similar cases that could later be referenced as a way of finding out how similar problems were resolved previously. This system uses a 'case based reasoning' approach to providing solutions to questions asked by helping the enquirer to find relevant information from the knowledge base. It uses a search mechanism based on key words? To produce a list of documents relevant to the query.

Interpretation of work activity at Comptel’s Customer Support Centre

- A customer contacts the customer support centre with a problem about the product using any of the three help lines.
- If it is a minor problem, then a customer support centre operator immediately responds with advice on how to resolve the issue of concern.
- On the other hand, should the problem be a major one, then the customer support centre operator asks to telephone the customer back at a later time. In the meanwhile refers the case to the ‘specialist group’ who investigate the issue and advises the operator about a suitable solution. Then the operator telephones the customer back to give the solution to the problem.
- However, if the problem is complex such that neither the ‘specialist group’ is able to resolve it, it is then referred to the customer support manager who is an expert. The manager will conduct his/her own investigations and also draw from his experience and expertise in deciding on which judgement will be most suitable to resolve the issue. Once an appropriate solution is decided upon, it is advised to the specialist team who in turn pass it on to the operator and finally the customer.

See Figure below for a pictorial illustration of Comptel’s operational structure

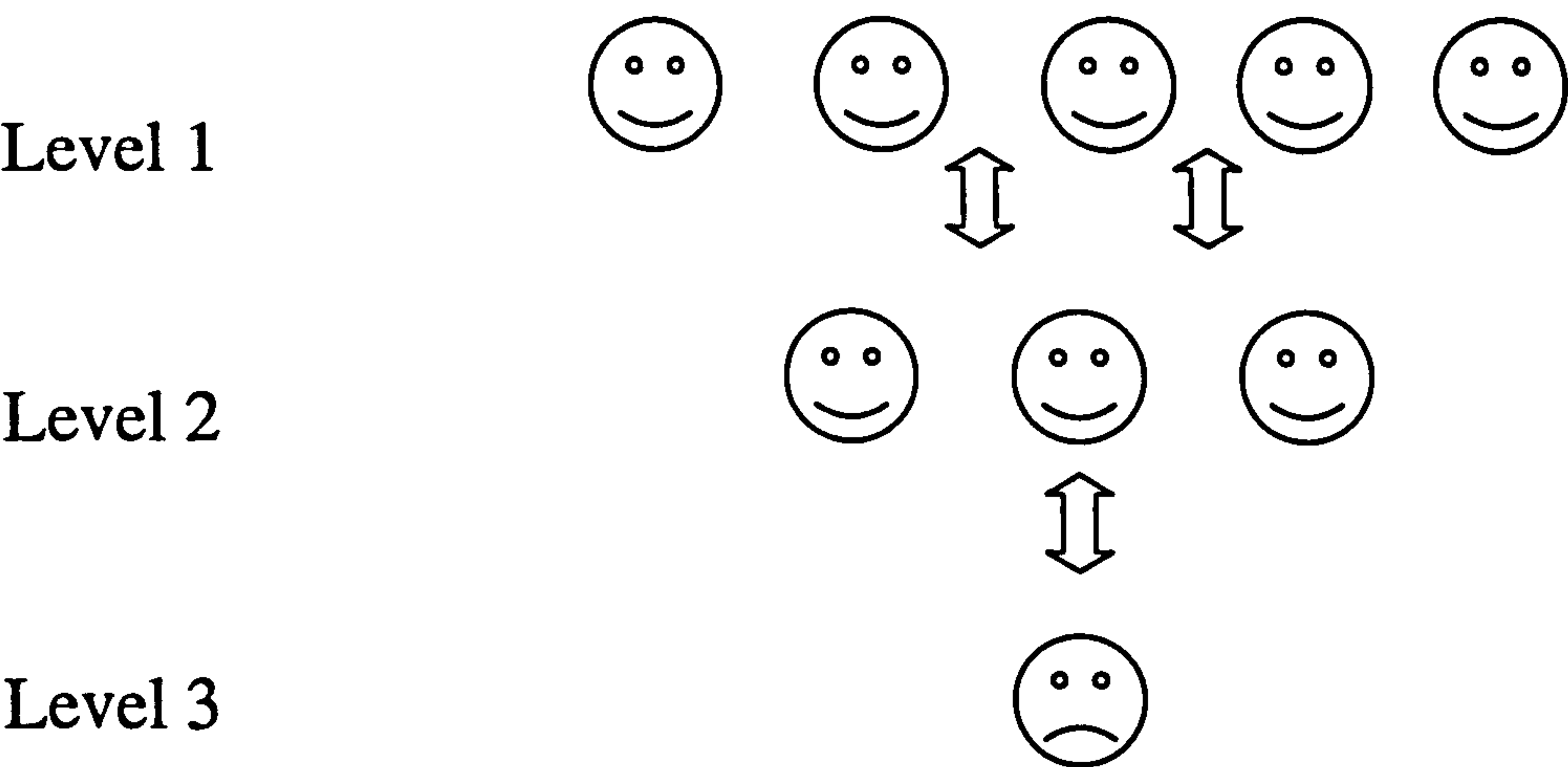


Figure presents a levelled hierarchical operational structure of the Comptel Call Centre. (Operations at level 1 seem to have no direct link to the expert at level 3?)

Appendix A - 3

Tools to be used

Open-ended questionnaire

Note pad

Pen or Pencil

Audio Recorder

Digital Camera

Methods and issues to consider when gathering data

When interviewing staff

Audio record discussions including telephone conversations if possible, otherwise take notes whilst interviewing and observing.

Focus areas - When observing workers:

- Collaboration and patterns (audio and visual)
- Cultural norms in communication and practice
- Co-operation and assisting each other
- Learning and sharing of knowledge

Other relevant areas to focus on:

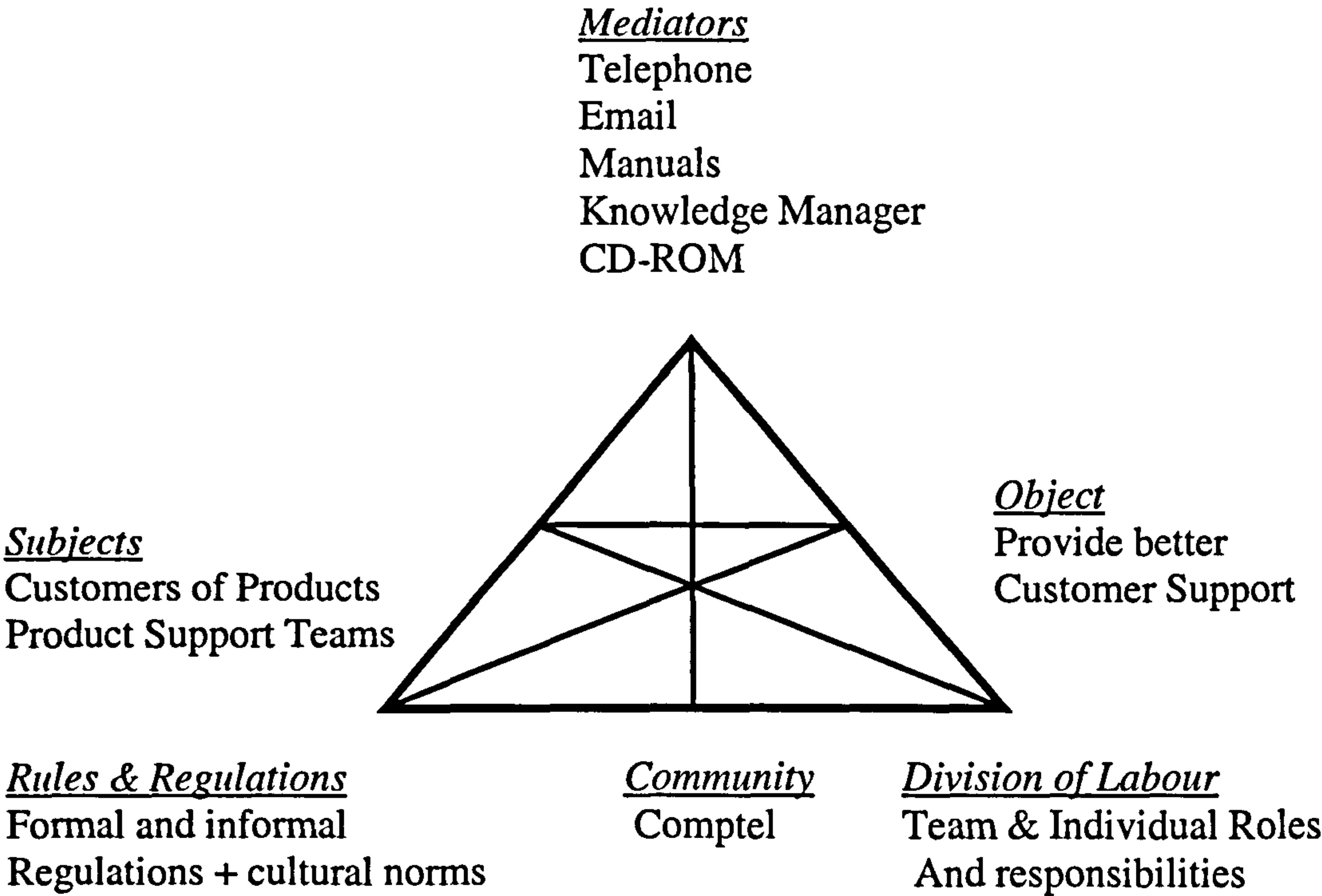
Different types of Learning

- a) Reflection-In-Action - occurs at individual level
- b) Domain Construction - occurs at team/group level
- c) Perspective taking - across teams (team to team)

Appendix A - 4

Triangle representation of activity at Comptel

A triangular representation of work activity produced from the background reading of information presented on CD-ROM.



Appendix A - 5

Questionnaire

1) Finding out about Comptel

Tell me a bit about your organisation.

.....

.....

.....

2) About Comptel’s products and services

.....

.....

.....

3) Job rotation system

.....

.....

.....

4) Staff Training

.....

.....

.....

What sort/level of training is given?

.....

.....

.....

New customer needs, are they addressed within the training?

.....

.....

.....

What changes occur to the training and how? How often?

.....
.....
.....

5) Comptel Knowledge Manager

.....
.....
.....

6) Identify activities (what they do).

Tell me a bit about the project.

.....
.....
.....

Briefly explain how you normally go about it.

.....
.....
.....

What are the main activities?

.....
.....
.....

What is the objective or goal of the activity?

.....
.....
.....

7) Identify actions

How do you share knowledge and skills on how to do perform work activity?

.....
.....
.....

How do actions feed into each other's work?

.....

.....

.....

8) *Identify operations*

Why do you do what you do the way you do it?

.....

.....

.....

9) *Rules*

Are there rules or guidelines to follow when giving advice to a customer?

.....

.....

.....

10) *Community*

Do external factors from the environment (computing industry, new developments in computing, business goals at Comptel) affect the way you work?

.....

.....

.....

Do these factors change from time to time?

.....

.....

.....

11) *Tools or artefacts (Mediators).*

What tools e.g. manuals etc do you normally use, when and why?

.....

.....

.....

Support for co-ordinating actions within an activity.

.....

.....

.....

Is the software in use dedicated for the task?

.....
.....
.....

12) *Participants perceptual understanding of activity*

Do they work competitively? If so, how does that affect the sharing of ideas

.....
.....
.....

13) *Outcomes*

What is the desired outcome of the activity?

.....
.....
.....

Appendix A - 6

Incorporating basic concepts of Activity Theory within the data gathering method

<i>Activity Theory Concept</i>	<i>Issues to address</i>	<i>How to analyse</i>
Tool / Artefact Mediation	The interrelation of tools and activity.	Observations.
Context	What aspects of the subject of investigation affect the way activity is performed?	Activity system triangle. Open-ended questions.
Cultural-historical development of activity	How do changes in social and cultural aspects of the community shape activity and tools used?	Review documentation. Observe work practices, Interview participants.
Consciousness	What human motives or intentions are reflected in activity?	Observe work practices and communication patterns.
Object-Orientedness	How closely aligned are the human's objectives, to those assumed for the tool.	Analyse tool design. Evaluate tool usage through observations.
Development	How are tools used? How do they evolve and shape activity?	Understand how tools are used as usage unfolds over a period of time during usage by observing and asking questions. Monitor developmental changes to activity as it unfolds.
Mediation	What tools shape the way individuals interact with reality in this activity?	Using observations, look for structural properties of tools in use in terms of shape, size, material, knowhow on usage.
Internalisation and Externalisation.	How do external mental representations of activity correspond with or shape internal ones?	Observe work practices then ask open-ended questions to find out. Look for breakdowns in activity
Functional Organ	Establish the perceived use of the tool by the human in relation to the intended and actual use of tool.	Open-ended questionnaire. Interview. Analyse tool usage through observations.

Appendix A – 7

Questions to reflect on when gathering and analysing data

- What are the motives of the team members as they perform certain actions?
- Are they aware of their motives or not.
- What breakdowns or conflicts can be observed during activity that disturbs the flow of operations bringing them back to action level?
- What routine actions are performed?
- Do these actions change to become operational?
- To what extent does technology facilitate or restrict/prevent the achievement of user goals? Does technology provoke or resolve conflicts between goals.
- How easy or necessary is it to integrate Enrich into this activity in terms of user requirements both social and physical, how about environment aspects e.g. tools, resources, rules?
- Analyse current mediator's support mechanism for mutual transformations of activity, learning, cognition, reflection and articulation.
- How will Enrich support or intended to support human actions in this context?
- Does collaboration or sharing of knowledge or even learning occur? How?

Appendix A – 8

Thoughts on Data analysis

- Extract key-words to work with (from the Activity Theory framework)?
- Plan of areas to focus on when gathering data

- November 1999

<ul style="list-style-type: none">• About the Organisation• Products and services• Job rotation• Staff Training• Comptel Knowledge Manager• Identify Activities (what they do)• Identify Actions (how they do it) <p><i>Consciousness</i></p> <ul style="list-style-type: none">• Motives (Awareness)• Breakdowns or Conflicts• Operations (Routines, Change)	<ul style="list-style-type: none">• Rules• Community• Roles or Division of Labour• Outcomes• Mediators• Perceptual knowledge of current mediators and Enrich• Collaboration and patterns (audio and visual).• Cultural norms in communication and practice.• Co-operation and assisting each other.• Learning and sharing of knowledge.
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Appendix A – 9

Conceptualisation of work activity at Comptel

December, 1999

Data presented below shows a combination of notes taken, points taken into consideration and personal transcriptions of various data types used as sources of information during data gathering.

The customer support unit is mainly concerned with rendering online help on Comptel products to customers mainly covering the European and African regions. Two other customer support units exist; One in the Asian continent, and another in the United States which covers South America and Canadian regions. The main world wide customer support division is the one based here at the headquarters of the automations and drives for Comptel worldwide.

The operational structure of the customer support unit is divided into four parts as shown in the diagram below:

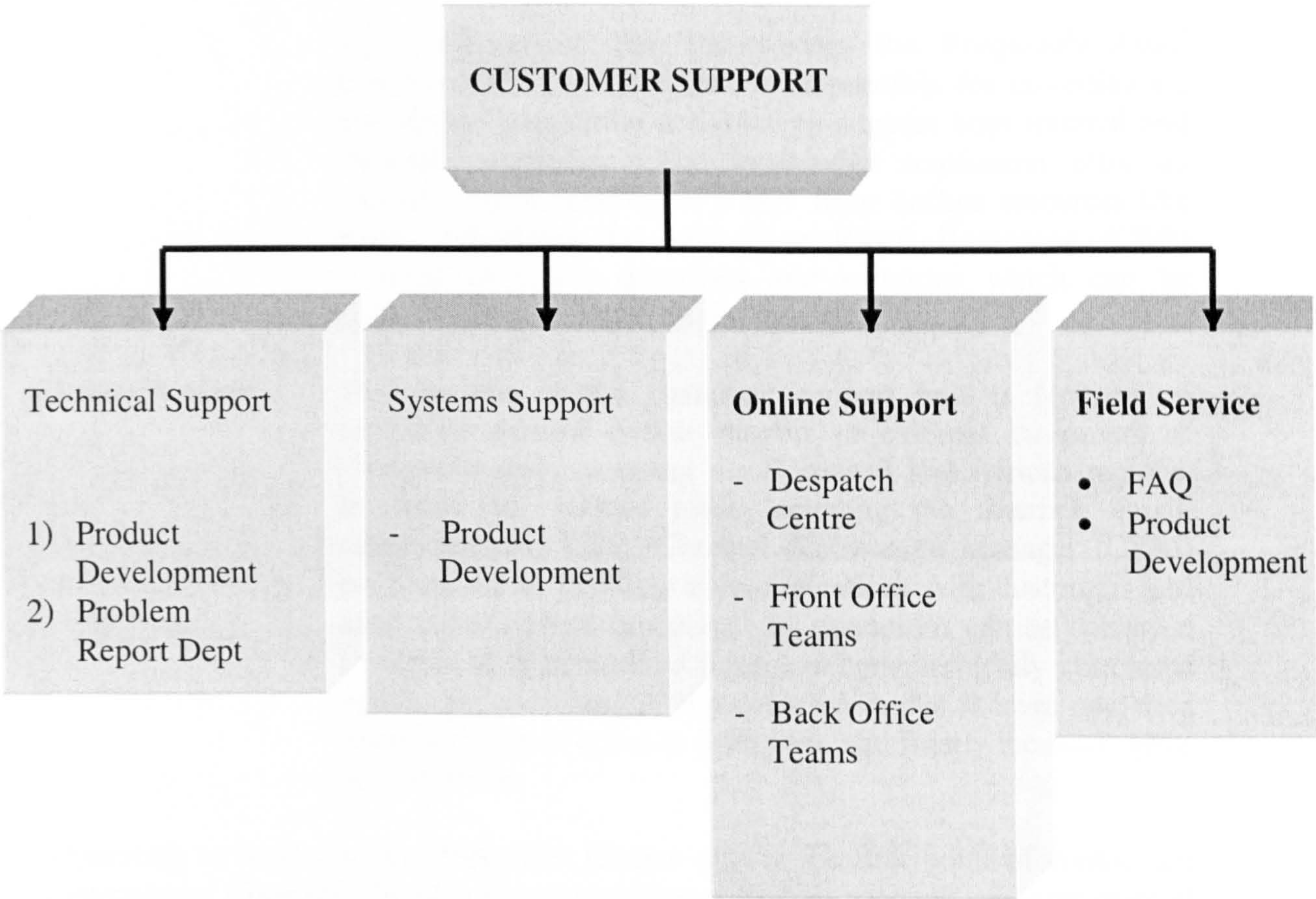


Figure shows the four parts that make up the customer support unit of the automations and drives division at Comptel headquarters

The four parts can be understood in terms of operations as described below:

Technical Support - Is concerned with addressing all technical aspects of the products support and also includes the product developers.

Systems Support - Combines a good understanding of the customer's business operations and systems currently used by the customer as well as technical knowledge of the new product (system) so as to support the customer in integrating complex new systems into the customers' already existing systems.

Field Service - Offers support services to both internal (units within Comptel) and external (Comptel customers outside the organisation) customers of Comptel which includes the provision of spare parts to subsidiaries of Comptel worldwide. This support is offered in three ways through the provision of *local support* internally to various units of Comptel, *technical support* which is also offered internally mainly to the automations and drives division at Comptel headquarters. Finally, support is also provided externally to customers of Comptel through the *development department* worldwide depending on the product.

The field service also incorporates the *Frequently Asked Questions* (FAQ) unit which is responsible for co-ordinating knowledge acquisition activities to support both internal and external customers. The knowledge acquisition activities includes the generation of FAQs from hotline resources like email, telephone, fax and Case Based Reasoning (CBR) systems to create questions and solutions which can be consulted by customers on the internet.

Online Support - This section of the customer support unit is focused on providing general online support to external customers of Comptel mainly covering the European and African regions. In doing so, various tools including the internet, email, telephone, fax, CBR, Comptel Knowledge Manager (CKM) etc are used to facilitate communications with customers and also to co-ordinate functions. Its operations can be portrayed in terms of a distinctive three level hierarchically structured operations consisting of the *despatch centre* at level one, then there is the *front office* at level two, and finally the *back office* at level three.

Operating at *level one*, the **Despatch Centre** unit is the first point of contact for customers of Comptel who experience problems with their products. A large team of non-technical operators with basic education mans the centre. Communication and language skills are particularly important especially English and German since these are the main business languages used to communicate with customers. The operators are given on the job training on how to handle customer inquiries in terms of what to ask for so as to obtain the right information about the problem from the customer.

Enquiries are received through any of the following methods, telephone, email, fax, internet etc. Once received, the information is entered into a computer system which connects to a database so as to make a *problem case* and *allocate* it to a team supporting that product at the front office. This way, everybody working on that particular product can then see the new problem that has been entered and also note the person dealing with it.

The **Front Office** operating at the *second level* of the hierarchy forms part of the online customer support unit. It mainly consists of several teams consisting technical people with each team specialising in supporting a particular product. Staff working at this level, take-up cases entered into the database by despatch centre and attempt to resolve them. Sometimes customers with pending cases tend to contact the front office teams directly instead of the despatch centre. Paper based manuals and online computer tools like CKM, Case Based Reasoning (CBR) system are used as support materials to help in resolving case problems.

Operating at the *third level* of the hierarchy, the **Back Office** mainly deals with difficult or complicated cases. These cases are normally referred by the front office. To resolve the case, the back office normally begins by obtaining as much information as possible about the problem from the problem author at level two and also the customer. Once adequate information about the problem is obtained, the back office attempts to simulate the problem and also apply a suitable solution as part of the investigations. Should further investigations be required, manuals, online materials and also specialist teams like the product developers are consulted about the problem. In the meanwhile the customer is also informed about the actions being taken. Once the problem is resolved, the solution is directly given to the customer and the problem author in the front office is informed. Customers can only contact the back office to follow up a case if they know it is being dealt with there and also if they know the contact person. The back office mainly consists of the Problem Report Department (PRD) staff that deals with extremely difficult cases only referred to them by front office. Cases being dealt by the PRD can take a long time. Field service engineers also contact product development if they experience problems while at the customers' site.

Conceptualising a problem solving scenario

- A customer buys a product from Comptel.
- Customer experiences a problem with the product.
- To resolve the problem, the customer will do one of the following:
 - Read the paper based manual that comes with the product.
 - Read the online manual or support material relevant to the product.
 - Contact the Customer Support Hotline for help.
- If the customer decides to contact the customer support hotline, then the telephone call is received at the Despatch Centre.
- The Despatch Centre staff will then ask for information about the nature of the problem and also get the customer contact details as follows:
 - Customer's full name and address
 - Telephone number, email or fax
 - Product name and code
 - Brief description of problem

- The Despatch Centre staff will enter these details into a database, therefore creates a case which is given a unique reference number for identification purposes. The team supporting that product at level 2 (front office) together with anybody else working on that case is then able to access this information.
- The hotline team supporting this product at level 2 (front office) will then pick up this case and contact the customer directly to try and resolve the problem.
- If not able to then to provide an answer immediately, they will then try collect further information about the problem and also advice the customer how long the problem will take and what is being done about it.
- If the customer presenting the problem is using the Premium Hotline, it means they hold a Comptel Card which is a first class service. Therefore, their case is treated as a priority case. This means that the customer must be contacted within 3 hours to provide solution or advice on what is being done and how long it will take.
- If the problem is considered *difficult* during the assessment then it is passed down to the Back Offices.
 - The case will be considered closed (at level 2 front office) with comments on the nature of problem and what has been done about it so far entered into the computer system.
- In the Back Office staff there will try to resolve the problem by consulting various sources including Product Development and Problem Report Department. If they fail to resolve the case, then they hand the altogether to the Problem Report Department. If this happens, the case is considered complicated.
- Complicated cases are dealt by the Problem Report Department which operates at the third level as part of the Back Office. Cases referred to this unit take a long time to resolve because they are usually major problems. The PRD will try to simulate the problem on their machines in an attempt to resolve it. They will also contact Product Development together with other sources including Field service (front office) if need be to visit the customer on site.

Appendix A – 10

Generating ideas on Data Analysis

February 2000

(Reading from Bødker in Nardi, 1996, pp.145 – 174)

Identify the various activities in which the Enrich tool is used by asking the following questions to find out the role played by the tool in use.

- Who are the users?
 - What are the objectives (internal and external) of each user group?
 - In which activities is the tool used? (Why is a particular activity taking place?)
 - Can the mediation be characterised as *tool*, *medium*, or *system*?
 - Then do the *why* (activity level), *what* (action level), *how* (operation level)?
- This type of analysis could reveal the reasons for designing the tool in the way it was done. Use the levelled approach to analysing data as follows: (see also page 154 of Nardi,1997)

<i>Activity level</i>	- ask <i>why</i> something takes place?
<i>Action level</i>	- ask <i>what</i> takes place?
<i>Operation level</i>	- ask <i>how</i> it is carried out?

- When studying artefacts in use, it is better to focus on their role as mediators (tools, computer).

Does the artefact in use help to focus our attention on the 'real' object(ive)?

Look for *breakdowns* and *focus shift* as indicators of problems or something interesting?

- These could be openings for learning e.g. deliberate or not deliberate actions.
- Articulate the 'otherwise unarticulated' e.g. if someone was asked to explain how they breath or drive (we do it, but it is difficult to explain).
- Investigate focus shift to determine whether they are breakdowns caused by the computer application as a result of poor design.
- Conduct a historical analysis of the artefacts and the practice in order to understand / learn about the present shape and use of an artefact.
- Are there any breakdowns in the actions or operations in which a computer tool is used?
- Think and use Engeström's contradictions in the way tools, objects and subjects are seen. These could be contradictions between e.g. the tools used and the objects created or the norm of the practice.

Still working with the idea of levelling, distinguish different aspects of the computer application's support mechanisms in terms of Physical aspects e.g. support for operations.

Analyse relevant objects and subjects of activities at two levels namely:

- Contextual level in order to situate (specific use) the artefact in the web of activities that may exist.
- Identify categories or items of things to look for in the analysis.
- Prepare a historical account of the work practices.
- Select interesting sequences for closer inspection.
- Map those interesting situations onto the triangle then analyse them according to focus shifts and breakdowns.
- Situate artefacts historically and in the web of activities and state how the tool fits in to support these, how and since when?
- Look for contradictions in the use of the tool to those originally (purposes) intended.
- What objects can I work with when using the Comptel Knowledge Manager?
- Record the state of overall activity e.g. the description and lists of documents, cases, deadlines, the contents of cases etc.

Interaction analysis – Do a detailed investigation of the interaction analysis of people while they interact with each other and objects of the environment.

Work setting – do an analysis to focus on joint definition of accomplishment of work at hand, organisations of interaction, use of supporting technologies and artefacts.

Appendix A – 11

December 1999

Summary of focus areas for the analysis;

- Role of artefacts as mediators
- Identifying breakdowns and focus shifts as indicators for problems
- Current tool support mechanisms for operations
- Conflicts or contradictions in the use of tools compared to the originally intended purposes
- Interactions of people with each other and environment including collaboration and sharing of knowledge as in learning from each other's experience
- Joint definition of work accomplishment

Identified tool Users:

- Despatch Centre
- Front Office
 - Technical support, Systems support, Online support, Field service
- Back Office (still Customer Support?)
 - Online support, Problem Report
- Other Units within Comptel
 - Product Development
 - Sales and Marketing Department
- Other Comptel customer support centres worldwide
- Customers of Comptel worldwide (limited access)

Identified Objectives

Objectives are perceived in two categories of *internal* and *external* types. External objectives are common to all units and also include the environment. Internal objectives are relevant only to particular units as indicated in brackets.

- To resolve problems with Comptel products (external)
- To render efficient customer services (external)
- To create a case problem and refer it to the right product team (internal, DC)
- To solve case problem (internal FO/BO)
- Render assistance in resolving case problems (internal BO/PRD/PD/FAQ)

Identify Activities in which current tools (computer tools only??) are used.

- Creating a problem case about a product (DC)
- Allocating a problem case to the appropriate team (DC)
- Resolving problem cases (FO online support)
- Resolving difficult or complicated problem cases (BO)
- Creating FAQs (FAQ)
- Obtaining feedback from customers (form?)

Appendix A - 12

Analysing identified activities in terms of levels of activity (Leont'ev, 1978)

<i>Activity Level</i>	- Creating a problem case about a product (DC)
<i>Action Level</i>	- Ask customer for name, address, product name and code
	- Access the right interface on tool and type in these details
<i>Operation Level</i>	- Enter customer data into the database
<i>Activity Level</i>	- Allocating a problem case to the appropriate team (DC)
<i>Action Level</i>	- Search on product name or code to find the right team in the database
	- Type in your description of the problem
<i>Operation Level</i>	- Select the team supporting that product
<i>Activity Level</i>	- Resolving problem cases (FO online support)
<i>Action Level</i>	- Search for similar problems and solutions in the database
	- Consult product manuals, other team members or staff in the back office
	- Contact customer for further details about the problem
	- Give solution to customer or advice about actions being pursued
<i>Operation Level</i>	- Conduct investigations to find solution to problem.
<i>Activity Level</i>	- Resolving difficult or complicated problem cases (BO)
<i>Action Level</i>	- Try to simulate problem to find out cause and possible solution
	- Check manual again and consult with product development
	- Advise customer and problem author about solution to problem
<i>Operation Level</i>	- Conduct further investigations by duplicating problem
<i>Activity Level</i>	- Creating FAQs (FAQ)
<i>Action Level</i>	- Read through the comments made by hotliners on closed cases reports and pick out interesting points to form questions.
	- Type in solutions to the question and provide links to documents which provide further information e.g. in the manual etc.
<i>Operation Level</i>	- Prepare questions and answer for referencing.
<i>Activity Level</i>	- Obtaining feedback from customers (form?)
<i>Action Level</i>	- Ask questions to customer while attempting to resolve problem
	- Read email or form feedback from customer via internet, fax etc
<i>Operation Level</i>	- Get the customer's view of solution or problem.

Appendix A – 13

Classifying mediation according to *Tool, Medium* or *System* using the levels approach

	System	Tool	Medium
Activity Level (Why)		To make products usable.	Collaboration
Action Level (What)		Receive problem/s from customer, thereafter find solution by checking online information about product, consulting manual as well as other people within the customer support unit. Sometimes refer problem to a more qualified person.	Creating problem cases by typing in information about customer into the tool. Interpreting cases already on the system in order to understand.
Operation Level (How)		Resolve customer problems or case about products using online help tool and manuals.	Consulting when working on cases.

Figure portrays important ways of mediating between users and their surrounding (reading from Nardi, 1996) in terms of System, Tool, and Medium.

Question

Did the mediator in each case help them to focus attention on the object of resolving customer’s problem or was focus redirected somewhere else like learning how to use the mediator?

Reflections and ideas on *identifying contradictions* in the focus areas of:

- operational aspects of the case study
- information flow between units (or mapped triangle components), to and from
- activity and levels of activity
- providing feedback, expectations, objectives
- constraints, for they represent recipes for selecting or calculating things
- oppositions between things, concepts, views, groups of people etc
- what negotiations are necessary between these conflicting parties?
- organisation structure as seen by the interviewer versus as described by the interviewee

- authorities in terms of control, shared motive, perception of the tool and its use
- description of the tool and the actual tool

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Considerations for interpreting and modelling activity systems

Then interpret these contradictions using the Activity Theory framework in order to ‘make sense’ of design implications. Contradictions represent initiations or opportunities for new or further developments for they are obstacles or hindrances for design. Contradictions help us understand the world. After identifying contradictions, classify then according to Engeström’s (1987) illustration i.e.

- contradictions within and between (two) activity systems
- contradictions between related, internal and external activities with the central activity can be seen as the driving forces in the development of the central activity.
- Identify the central activity (very difficult!) to focus on
- Discuss the weaknesses of using (triangle) this approach to analyse the case study

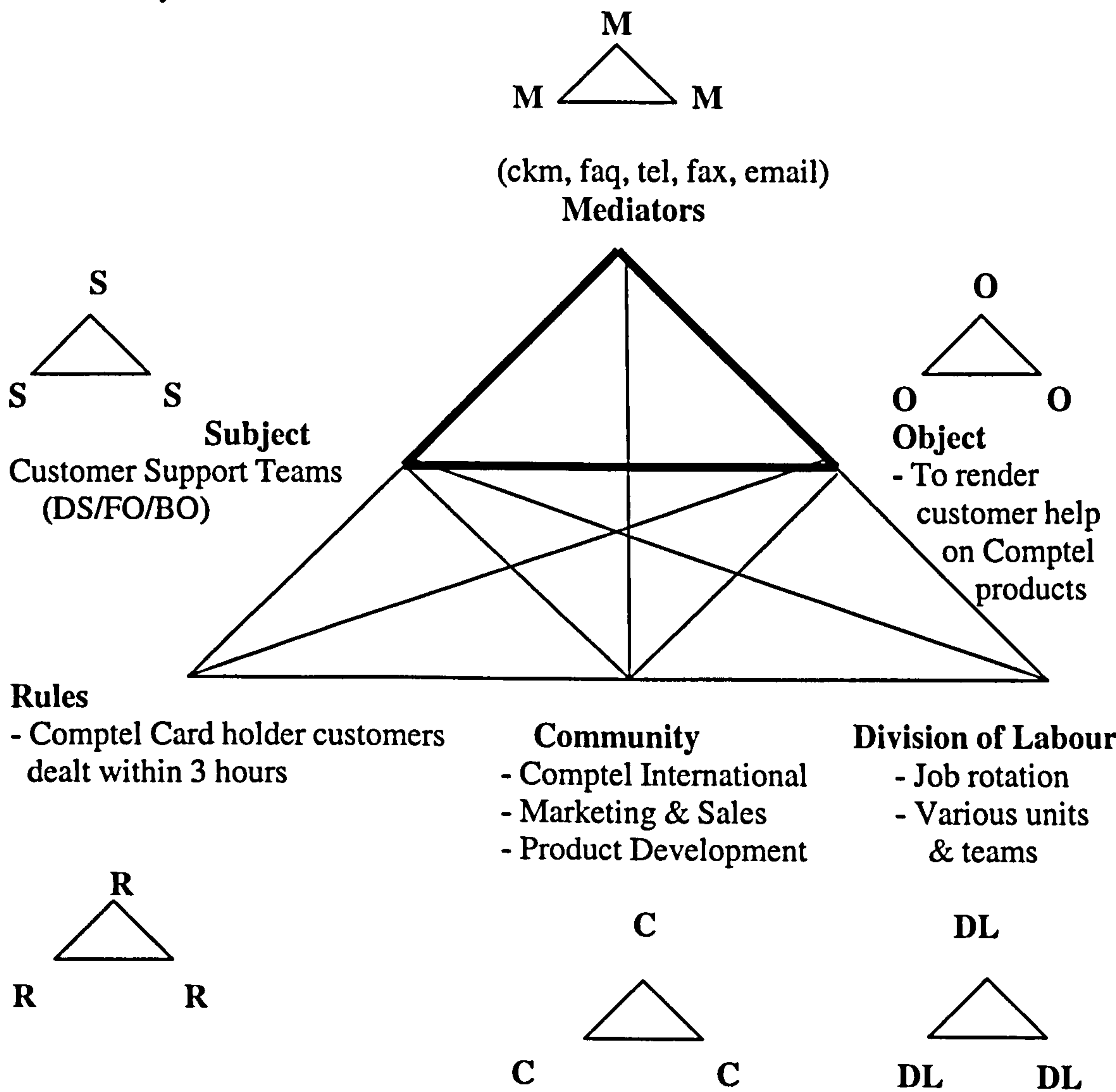


Figure showing the central activity system together with the other activity systems representing a complete system of each component.

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Contradictions identified

February 2000

- 1) Flow of operations – Conflicts relates to the flow of operations between units. For example, variations exist into the ways in which difficult cases are determined and handled from one unit to another. Rules for resolving or further referring difficult cases are not made explicit and not fixed, which results into the duplication of effort through unnecessary redirections. When dealing with a *difficult case*, the front office either pass-the-case-down to the back office or by pass them and go further down to the problem report department. In situations where the problem is not perceived to be difficult by the problem report department, this overburdens the problem report department who are supposed to be dealing with much more complex cases. Therefore the case could end up being re-directed to the back office.
- 2) Job rotation system on one hand presents internal disturbances *within* the team operations (team culture/spirit) in the senses that it affects the division of tasks when a member is suddenly moved or a new team member is introduced to join the team without prior warning.
 - 2a) On the other hand, the idea of enforcing flexible work patterns through random (no prior timetable) rotations could entail continuous training in (*between*) the various team operations at the expense of specialisation.
 - 2b) This job rotation system can also affect relations *between* the customer support and customers as they attempt to make a follow up on who is dealing with their case as customers are not made aware of these rotations. Customers normally know who is dealing with their case and what is being done, but once that individual is moved to another section there is no telling who is working on their case until someone contacts the customer to give feedback.
- 3) There exist conflicts into the staff expectations or purpose of the Enrich tool being developed. FAQ leader thinks of it as an additional tool to the many already existing tools. “We do not need so many tools, it would be nice to have one tool which can handle several work features within.” Management think Enrich is the extension of the Comptel Knowledge Manager?
- 4) Effective decision as to what makes a case difficult depends on so many issues including the experience and know-how of the individual dealing with the case, the duration estimated for completion of the case. This conflict exists between the front office and the back office especially problem report department.
- 5) Conflict in the internal objectives (versus external or overall) of the FAQs of distributing know-how about how to resolve problems to that of other support units’ of rendering information about how to resolve problems?

- 6) Any customer support staff can create a case e.g. despatch centre, front office – hotline staff, field workers, etc. This approach can create confusions into the division of labour.
- 7) The FAQ's idea of co-ordinating knowledge acquisition refers to supporting customers and staff about finding the right documents to solve the problem but does not include the process of arriving at that solution.
- 8) Duplication of effort between the dispatch centre and front office staff when entering customer data, receiving queries from customer, preparations of problem reports can be done by any staff. This causes confusion as to the flow of operations.
- 9) The FAQ leader participated in the Enrich trials with another organisation from the Enrich project consortium during which time he got frustrated with the slowness of the tool in finding the right things when searching. The disappointment in speed shows that the tool was misunderstood to be some database facilitating easy access and retrieval of right information instead of a knowledge management tool for sharing knowledge. Conflict into the understanding of how the tool operates.
- 10) The rule for dealing with Comptel Card customers within two hours does not specify what 'dealing with' mean. The conflict here arises due to the various interpretation of the concept which could determine the type of actions to be taken.
- 11) In the despatch call centre, there exist a problem between wanting to 'communicate' verbally and be sociable and wanting to answer customer enquiries. So the use of an email system was introduced when talking to colleagues.
- 12) Customer support team face contradictions in wanting to collect suitable questions for the FAQ and also concentrating on resolving as many cases as possible so as to hit the target or improve ratings on the weekly bar chart.
- 13) Some conflicts exist at online support (despatch centre and front office) when answering calls in foreign language, in the meanwhile there are no language training courses?
- 14) Contradictions in the understanding of the objectives of the tool (Enrich). Mistaken for a search engine "too slow, doesn't always find the right information." Enrich is not depended on speedy, it is meant to facilitate the sharing of knowledge by presenting relevant information from similar situations?
- 15) Hanging knowledge 'ontologies'; discussion list not linked to cases, operators sometimes make their own notes to remind themselves of certain things in future, this tacit knowledge is only explicit and useful to the author. Weekly team meetings are held to reflect on and discuss the difficult cases of the week and also reflect on that week's performance, also to plan for the coming week.

These discussions are formally recorded and the current tool is not used to support these meetings.

Appendix A – 16

February 2000

This document attempts to transfer activity theoretical concepts into design concepts using the Comptel case study. This effort uses Activity Theory's notion of *contradictions* in order to predict solutions to those problems and map them in the form of a design decisions as shown in the table below. Contradictions could exist *within* the internal system or in *between* one internal system and another, or *between* an internal system and the environment (e.g. customer).

	Identified Contradiction	Type of contradiction	Design Decision
1	Flow of operations	<i>Between</i> one internal unit and another as a result of variations in procedures for determining and handling difficult case.	Need to provide clear guidelines. Guidelines must be accessible in the same manner at all levels of operations.
2	Job Rotation System	Disturbances <i>within</i> the team in terms of work culture, team spirit and team operations. <i>Within</i> the individuals learning pattern. Rotating from one team to another could result into increase exposure to different functions and the expense of specialisation. <i>Between</i> customers and the customer support. Rotation means customer is not immediately aware of the dealing with their case when making a follow up.	Job rotation rota with outline of scheduled movements together with duration prepared in advance. A team of already skilled and specialised individuals could be established to handle emergency shortages in team staff.
3	Purpose of the Enrich Tool	<i>Between</i> user expected and actual functions of the tool.	Continuous re-assessment of the tool's functional requirements in liaison with the user.
4	Deciding which cases are difficult	Conflict <i>between</i> the subject resolving cases and the rule making systems due to lack of clear guidelines as to when a case should be considered difficult.	Need clear guidelines on what determines a case difficult.
5	Short term verses long	Staff experience conflicts	Need clear understanding

	term objectives.	<i>between</i> the objective of collecting FAQs for future references when resolving cases and the objective of increasing their ratings on the weekly bar chart through resolving as many cases as possible.	of how the different functions contribute to the common objective of rendering customer help.
6	Division of Labour	Conflict <i>between</i> the policy of flexibility in carrying activities and the division of labour in terms of responsibilities.	Clear responsibilities at all stages of the activity.
7	Interpretation of rules	Conflicts <i>within</i> the rule making system arising from variations in interpreting the meaning of actions to be taken in relation to the Comptel card holder customers who should be given priority treatment. What does to be 'dealt' with within two hours mean?	Clear guidelines of actions to taken should be made explicit and easily accessible at all times.
8	Communication	Conflicting purposes of the tool usage exist <i>between</i> the use of the telephones for communications amongst operators and also as the main communication tool used by customers.	Email was introduced for internal staff communications. Introduction of internal line answer-phone and recording system could be introduced.
9	Purpose of Enrich tool	Conflicting views <i>between</i> customer support team and management regarding the purpose of the tool. Customer support team perceives the tool and another search engine for retrieving the right information from the database or CBR, therefore expect functions that are associated to a search engine e.g. speed. Management on the other hand are of the view that even though the tool incorporates some of the functionalities of a search engine and a CBR, its	Need for continuous liaison before and during tool development in order to review and agree on functional and purpose of the tool.

		main purpose is to facilitate the sharing of knowledge or learning by presenting similar cases for referencing and enabling discussions around these cases. Therefore, the tool is a knowledge management tool not a search engine.	
10	Hanging knowledge	<ul style="list-style-type: none">- Breakdowns or missing link between discussion list and cases.- Customer support operator's own notes (tacit knowledge) not shared with others or linked to cases for future references.- Proceedings of the weekly team meeting are not captured into the system or linked to cases in anyway hindering the sharing of insights and experiences.	<p>Tool must link discussions to cases or discussions must be arranged around cases.</p> <p>Operator's own notes must be linked to cases and accessible by all.</p> <p>Introduction of tool features that supports the raising of an agenda and discussion of agenda issues online prior to the meeting. Same tool could be used to confirm or reject suggestions.</p>
11	Communication	Conflicts exist in wanting to provide international customer support while there is lack of training in foreign languages.	<p>A language training programme needs to be established as part of work.</p> <p>Tool needs to reflect a multi-lingua interface.</p>

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Comptel on-site visit, interviews and observational studies

November, 1999.

Briefing by Customer Support Manager about Comptel work operations.

About the Customer Support Division

The Customer Support Division is divided into the following parts namely:

- Technical Support
- Systems Support
- Online Support
- Field Service

Technical Support

These are responsible for providing support in all technical aspects of the products. It includes the product developers.

Systems Support

This unit get involved in situations whereby the customer wishes to integrate a complex system into their already existing business or systems. In such a situation, a customer usually doesn't know which system or software is most appropriate to use and how best to integrate this system with already existing systems. The customer usually has a concrete project that they are willing to support.

Online Support

This section of the customer support consists of the Frequently Asked Questions (FAQs) files, which can be downloaded as electronic version or printed out in paper form. Paper based information could be the announcement of new products from marketing. Then there is also the internal support engineers product information report available online. This could be for example the connection with another organisation from the Enrich project consortium. Also to be found at this level is the modification manual together with actual information for the internal sales force which could be for example the notification of products published on the intranet. This unit also consists of the Newsletter which includes both internal and external subscribers. There are also internet based online manuals which can be accessed by both the customer and the support staff. Then there is the web-based discussion tool and also email based discussions system. Also under this section is the Comptel Knowledge Manager (CKM) which is a system based on six document description of orange (combines CBR works and CBR answers) provided by this other Enrich organisation including pdf documents.

Field Service

This section provides support service to both internal suppliers and externals including providing spare parts to subsidiaries of Comptel world-wide. The field service support is provided in three ways:

- local support
- technical support (at headquarter)
- and development department (which is exist world wide depending on the product)

The knowledge acquisition for knowledge base includes knowledge engineers, FAQs (see hotline staff in the FAQ team for detailed information about this). The FAQs are written in MS Word then automatically converted into html then end up into a database?

Organisation of the Hotline

A customer will normally contact the Dispatch Centre with a problem. The dispatch centre operates at the first level manned by a team with no technical background who received basic training on how to describe and refer problems to the appropriate team supporting that particular product at the Front Office level which is the second level of the Hotline. The dispatch centre operators will ask the customer simple questions which will help them in deciding which specialist team to refer the problem.

The Front Office consists of small specialist teams of five to six people focused on supporting a particular product e.g. WinCC Teams operating at this second level are expected to provide a solution within a 30 minute time span. Should they fail to do so within this period then the problem is considered to be complex and requiring expert investigation. Thereafter, which the problem is referred to the experts at the third level who could be developers at the Back Office. Instead of passing the problem on to the back office, the team dealing with the problem at the front office may decide to pass it on to another team specialising in that product within the front office unit. The terms used in describing the product name when describing the problem assist the front office team in deciding which team to further refer the problem to within the front office.

The Back Office usually has the same interface configuration as the customers'. Speak to the head of unit. It consists of a single group of experts which includes senior technicians with expert knowledge on products.

Both the front and back office teams are supported by the Call Tracking System (CTS) which records information on which product has a problem, what sort of problem it is and how that problem was solved.

In situations whereby the problem is sent via fascimile, the fax is then converted to an email version which is then presented to the dispatch centre team as a query? The CKM makes it easier to find an answer and can also be used by customers to obtain knowledge about the problem that they are facing. CKM can also be used to find out information about other systems. The CKM is integrated with the CTS to offer an

intelligent search within the product support operations using the automatic hotline with Case Based Reasoning (CBR).

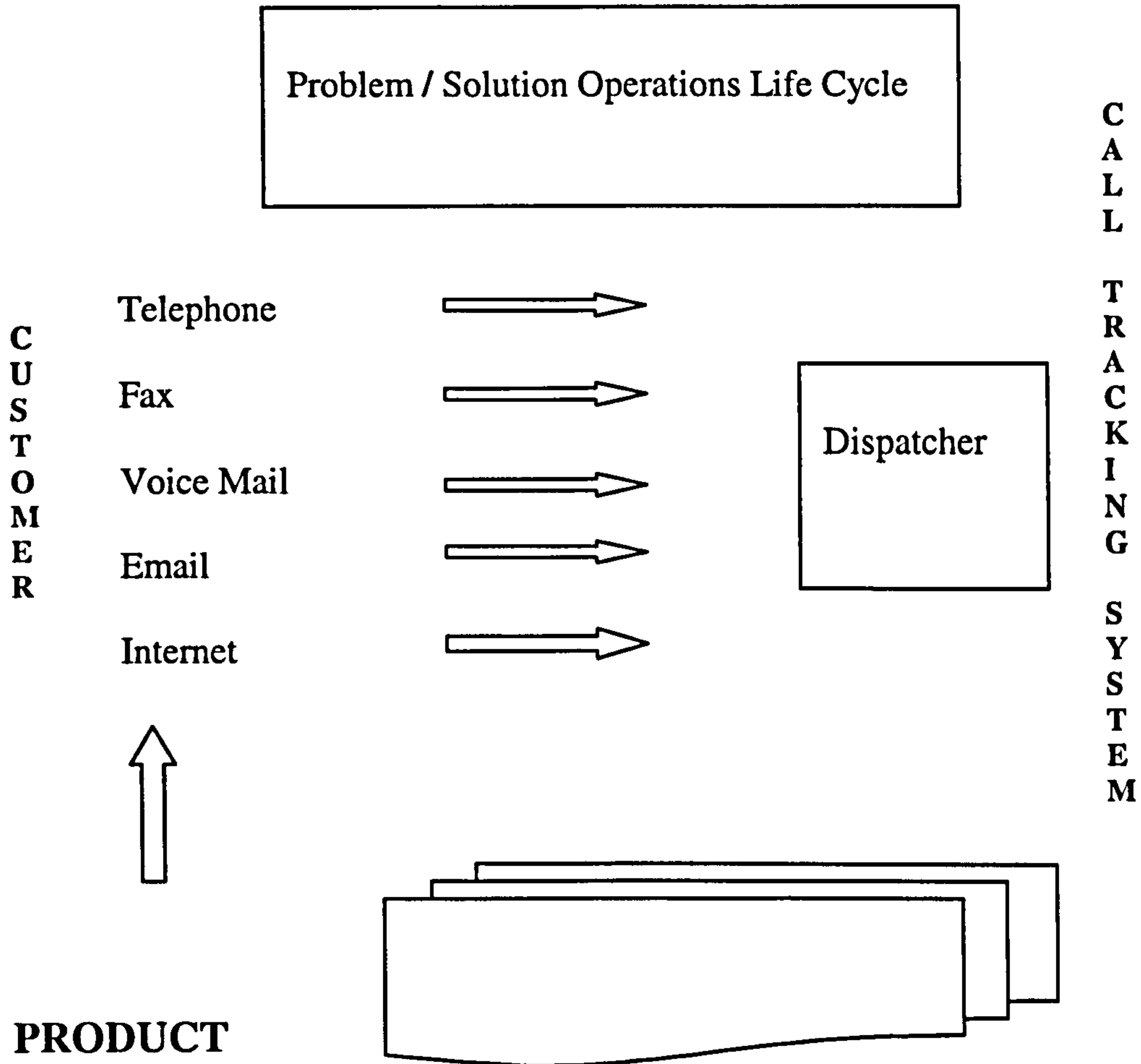
Human Machine Interface (HMI) team

Notes about WinCC product, supported by the HMI team.

The hotline tool is mainly used. The dispatch centre creates a hotline case for the problem. All we do is to wait for a call from either the dispatch centre or the customer. Then we check the project number and software being used by the customer. We can then contact customer in reply via email, telephone or fax which works both ways if the customer also wishes to contact us. All messages sent to the customer are stored as a way of obtaining a permanent record of correspondence. The customer message is prioritised if the customer phones using the premium cards. The message is then highlighted in blue to indicate this prioritisation into the system - meaning that the problem has to be dealt with within a maximum of 3 hours.

Each case is given a case number which is time stamped to indicate the time the problem was recorded and resolved. A description of the problem is obtained from the customer by the dispatch centre staff or front level team member who receives the call. The solutions given are time stamped automatically via email or fax when the closed button is activated. The hotline tool allows to search on key words for solutions within the system. It is also possible to search other hotline centres for solutions to similar problems. There are also some log files which help to resolve PC based problems, which is helpful to the dispatch centre when they face difficulties in defining the problems. A special team creates the FAQs after consulting with the hotline support staff (front office). The hotline system also allows one to draft own notes which are just for personal use. If you can't attend to the problem there and then, it is possible to ask the customer to call later or tell them you will phone them back. If the problem can't be resolved it is possible to consult with another team member or teams on how to go about it. We use all sorts of methods to do these consultations including face to face, telephone, email, manual, fax etc. All this informal consultation is not captured online.

I have not heard of Enrich but there is a discussion forum on the intranet for general discussions. We tend to have an average number of cases resolved per day. I receive at least 30 emails per day, about anything useful from these emails will be typed into the cases for ease of access and search purposes.



Teams Specialisation

Appendix A – 18

November 1999

Follow up questions from previous day's talk.

- How long does it take before a problem is referred to the *back office*?
- Does the back office deal directly with customers?
- In Comptel Knowledge Manager, what are the *six documents* about?

Questions for the Back Office

- What goes into the case closed report?
- FAQ draft notes intended for author's self use, what are they?
- Comptel card holder customers problems have to be dealt with within 3 hours? What does 'dealt with' mean in this context? Solved or just getting back to the customer?
- How long do they (back office) work on a case before referring it to the Problem Report Department? Where do cases normally come from?
- Does the Problem Report Department give their answer / solution to the Back Office or directly to the customer?
- Which units / sections does the Job Rotation involve? Where do members of the Back Office team come from?
- How about the Product Development team, do they have any direct contact with the customer?

Idea – perhaps draw some diagrams here for illustration purposes?

Interview with Human Man Interface (HMI) team leader supporting the product called WinCC.

Appendix A – 19

November, 1999

Interviewer - Approximately how many cases are referred to the back office?

HMI Leader - If I need more than an hour to work on the case, then I refer it to the Back office. I would normally access the back office interface on the the tool whenever the case is too difficult to solve within an hour. A customer whose case is referred to the back office must therefore pay extra money for this service.

Interviewer - Is that using the Comptel card?

HMI Leader - No, the Comptel card just acts as a first class service or priority treatment, which means we have to try and solve the problem within 15 minutes. We also send to the back office all cases that are not complicated but could take a long time to resolve. Thereafter the cases problem is resolved by the back office office, they then contact the customer directly once the problem is resolved.

Interviewer - Are there any problems or improvements that you would like to see introduced or resolved with regards to the tool's interface and usability?

HMI Leader - I tend to use Knowledge Base CD-ROM with WinCC product details. A customer can also look for solutions on the internet in the FAQs. Otherwise, I sometimes attach a document from the CD-ROM and email it to the customer. At times we tend to discover further problems within a problem which makes it difficult to set time for completing resolving the problem. In such cases, we would advise the customer on what is happening and how long it will take us to solve the problem. For example, I am at the moment still waiting for information from the development centre.

Interviewer - Is it easy to decide on who to contact for help? The back office or the development department?

HMI Leader - We have a list of who is using WinCC, so we can decide by looking at that list. If the problem is resolved, I then generate a problem report. A problem report can be prepared by front office staff, field service or sales people. The procedure runs as follows:

- A customer contacts the front office with a problem.

- Front office tries to solve the problem; if difficult then the problem is referred to the back office.
- Front office staff then prepares a problem report and that marks the end of their dealings on that case because it is now in the hands of the back office staff.
- Once the front office prepares a problem report, then the case is closed as far as they are concerned. The problem report department then takes over the case. A customer can also fill in a problem report on the web. That way, the report goes directly to the problem report department who then deal with it directly. The back office can take long to solve cases because they wait for answers from the product developers and consult with many other people from various sources. When the back office solves a problem, they normally publish it on CD-ROMS and FAQs. The intranet is used for FAQs.

With regards to open cases or pending cases, we allow the customer about three days in which to call us back and if they don't call we assume the problem has been resolved or doesn't exist any more so we close the case. The following items on the tool signifies as follows:

Customer Wait	- Waiting for an answer from the customer.
Engineer Wait	- Waiting for an answer from the engineer.
In Work	- Case is pending.
Closed	- Case finished.

Features of the system includes:

Kind of Service:

- Technical information
- Application information
- Problem Diagnostic
- Sales Product information

Caused by:

- Documentation (not enough or not clear).
- Hardware (not available or not compatible etc).
- Software (not compatible, difficult to use, etc).
- User error
- Incompatibility (versions, integration, etc).
- Systems limitation
- Configuration
- Lack of Knowledge
- Undefined

A system called TICKLER or short message is automatically generated in a form of an email. The dispatcher attaches an email to a document which then becomes a tickler.

Interviewer: What is a tickler used for? How does it work?

HMI Leader: We use it to support the following functions:

- Product Management
- Sales (ask product)
- Training
- Document department?
- Totally Integrated Automation (TIA) product management
- None (then call product development)
- Monthly report

A monthly report is a short report prepared for the team leader if the same problem persist or if complaints about the same problem are received from various customers. The team will then hold a meeting to discuss the problem. I worked in the problem report department before joining this team. I recently joined this team as part of the *job rotation* system which allows us to familiarise ourselves with different things (jobs) in different teams and units.

Interviewer - So how long do you stay in each area before moving to another unit?

HMI Leader - May be 5 months in each unit. It is not fixed. We tend to get training on-the-job in each unit. Sometimes I experience language problems when dealing with customers who are not German speakers. We are asked to learn English in our own time. I am able to tell what language to use when dealing with a customer simply by looking at the area from which the customer is calling from.

Interviewer - What are drafts?

HMI Leader - Well, if you find something new, then you put it in the draft as a recommendation for a solution which is later confirmed by the FAQ team is accepted. They (FAQ) decide what becomes a solution?

The interviewer drew the following diagram after the discussion with HMI Leader.

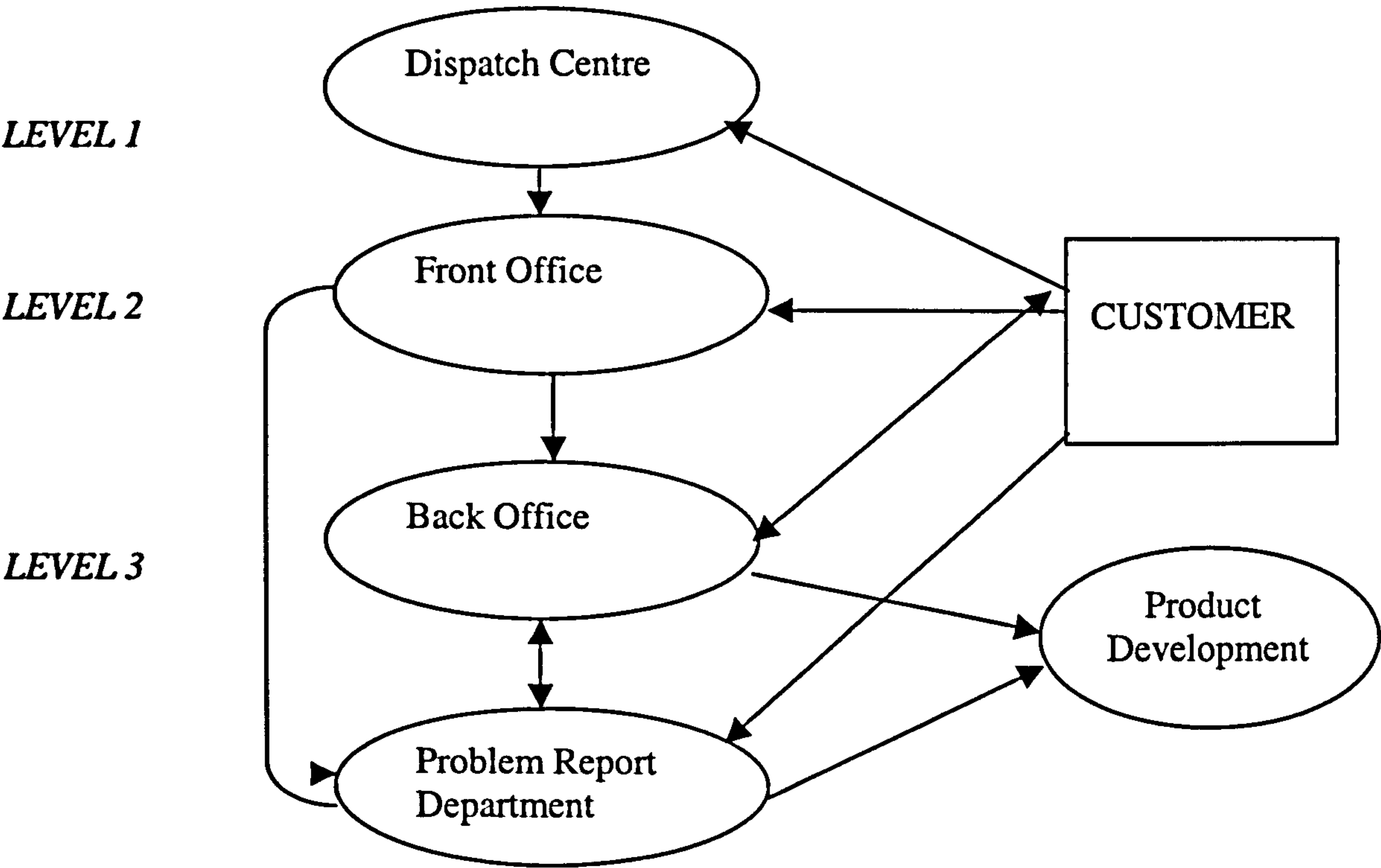


Figure showing the Problem Solving Flow

Question: How does the Sales unit fit into this representation?

Interviewer - So, is this the headquarters of Comptel Worldwide?

HMI Leader - This is the headquarters of the Automation and Drives division of Comptel. The company offers free language courses to learn English although employees need to find their own time to attend or do the course.

End of interview with HMI Leader.

Appendix A – 20

Translation of interview proceedings and notes made following observational studies at the Dispatch Centre

November, 1999

The call operator observed was retrieving email correspondences received from customers. The customer name on the email (header or body) is used to search for details of previous cases (problems specifications) in the database in order to prepare a case which could be accessed and seen by everybody working on that case so that they can all see the email (if it is a follow-up on a problem?) The email or fax once received is attached to a case and time stamped to indicate time of receiving and closing. The operator was working on an email received from a customer in Saudi Arabia. Sometimes the operator will use the product code in order to understand and describe the problem to the front office staff. The procedure may begin by the checking of the context as follows:

- Who is the customer (name, company, where)?
- What is their contact (address, email, fax, telephone etc).
- Rough description of problem to establish who to assign the problem to in the front office.

Interview with the manager - Problem Report Department (PRD)

November, 1999

Interviewer - Tell us about the problem report?

PRD Manager - The problem report is written in the Intranet using an html form which is automatically sent to the dispatch centre. This way, a report can be printed out in word to those without access to the internet. Some of the different reports that we work with include the *Product Safety Report*. The main difference between the problem report case? Is that hotline use the case view? Each problem report is given a unique case number for identifications or follow-ups. Once confirmation is received, then the problem is investigated and the customer is informed about the status of the investigation. A fault report is then entered into the master problem report with a unique number. Reports are then submitted to the head of department or unit. A systems test is then conducted. If the problem has been solved then the case is closed with comments on how exactly it was solved. After this has happened, an answer is then given to the problem report author to provide feedback. In situations whereby the problem cannot be duplicated, the case won't then be entered into the system at all. Therefore, the author of the problem is contacted for clarity or further information about the problem. About 70% of the problems

reported are not actually faults. If a problem is too complicated, we try to duplicate it, contact author, customer or engineers for further information and sometimes help. If the same problem is experienced by many customers, we recommend it for writing in the FAQs. If a customer contacts the hotline and the case goes to the back office, the back office could refer it to the engineering department. Only Comptel employees can write a problem report? Any employee can write a faulty report? If a problem can't be solved at all using these various approaches, then the service staff visits the customer to address the problem.

Interviewer - What is the difference between the problem report and the faulty report then? So how long does it normally take to solve a problem?

PRD Manager - The duration could on average be a few days or weeks depending on the problem. ATD TDINABT Systems Test, Hotline? The staff rotation system is not fixed either. The Time stamps are used as a remainder of the time period a case was processed through the recording of the time started and closed.

Interview with FAQs Team Leader and members

November, 1999

Interviewer - So, what does your team do?

FAQs Team - Our main responsibility is to co-ordinate the knowledge acquisition projects by generating questions from the Hotline sources like email, telephone, fax and CBR. We use hotline to choose the status of 'propose mode' then we pick information and create FAQs. Some FAQs are private (those in the intranet) whilst others aren't. We create FAQs concerning documents available to support the solutions suggested in response to the FAQ. I previously worked in the team supporting the WinCC product when we were building the hotline tool for that product. Hotliners used to create FAQs in addition to the normal duties but now it is a very busy unit. Therefore a new unit was created to deal with the creation of the FAQs – my team.

Interviewer - Do you always discuss as a team before deciding what goes in the FAQs?

FAQs Team - No, we do not always discuss before deciding what to put in the FAQs but sometimes we do. I suppose there are good and bad points but on overall, it would be useful. I also participated in the trials with Enrich. In those trials, I

experienced problems with the search engines when trying to find the right things as well as how to add comments in order to bring it back into the knowledge base. An improvement on methods for searching for new comments would be good even if it means to appear in the browser.

Interviewer - I understand that teams are also required to produce weekly bar charts to indicate performance levels, does the FAQ team also publish their performance level on these bar charts?

FAQs Team - We are not particularly keen on these bar charts in this team because the whole system [performance rating scheme] has created an unfair competitive atmosphere. You see, people are supposed to pose and reflect on the kind of questions that they gather for the FAQ. The introduction of the bar chart has meant that we [FAQs Team] now have extra work checking through submitted questions so as to include only those that are useful. People need to take their time and reflect on what they are doing instead of rushing to improve bar chart ratings.

Interviewer - How would you feel about the addition of a discussion space to the cases?

FAQs Team - We really don't like using too many tools because we may buy a new system altogether in future. Too many tools can be confusing. It would be good to have one tool handling many things e.g. email started, recorded and searched within the same tool. In-built email system could also incorporate email news or discussions. That would be good. May be also the inclusion of a list of new bugs in hotline could be good as an automatic update based on reference or request number. As you suggested, it would be good if these could be linked to cases in a searchable list.

Interviewer - So what features would you say are good on Enrich?

FAQs Team - Mainly the easy of integration with already existing environments or tools. It would be helpful to get a list of comments as feedback on FAQs from Hotliners so that FAQ could either change or rephrase the FAQs. Therefore one could do a search like, I want to see all comments added to the FAQ in the last week etc. This would be helpful to FAQ staff as well because they could see how they are performing. The possibility to add comments as in Enrich is really good but I was just missing the link to things.

Notes made following a follow-up discussions with the PRD Manager

November, 1999

The PRD Manager gave a demonstration of the Comptel Administration Tool which uses a dictionary to read key words. He offered a description of how the tool is used in their online catalogue, the use of the 'Fish eye view', the Query analyser and the use of short-cuts to automatically search the dictionary. A tool known as the *Parser* is used to pass all html files while eliminating all text files? They relate each document to the topic (title?) using a customer number?

This was not necessarily an interview, for it was much more of a feedback review of findings from interview discussions and work observations as a way of reporting back with comments to the Back Office Boss. During the briefing, a mention was made about pending future plans for the company i.e. change in the structure of the operations of the back office to form two separate units namely *Support Line* and *Service Line*. This is as a result of the current confusions in operations between the back office, problem report department and the field service unit (level 2). The future 'support line' unit will concentrate on in-house supporting of all hotline staff and customer queries online whilst the 'service line' unit will partly take on the duties of the field service staff, problem report department and a bit of product development duties. The service line staff will mainly be going out there to the customer to lender assistance at the customers' place.

Appendix B

EngiCom Case Study

Appendix B - 1

Field Notes and interview transcription

September 2000

This document outlines the final field study conducted at EngiCom.

During the study, value team leaders and members who had been closely involved in using the Enrich system during the trial period were interviewed. This was done so as to gather user opinions about the usefulness of the system within their work activity.

Interview with the team leader for the Technical Publications - in this interview transcript referred to as 'Respondent A'.

Interviewer: May be you can start by telling me a little bit about the work that you as a team do. What are the main duties of your team?

Respondent A: My team is mainly responsible for T-Publications.

Interviewer: Does that stand for Technical Publications?

Respondent A: No, just T-Publications, estimating targets for publications, report keeping etc. We tend to create our own version of these publications, which is usually an additional responsibility on our side. In addition, we are required to maintain EngiCom consistence, therefore, all these responsibilities kept diverting the team from using the Enrich system fully. It is due to these reasons that the system has not been fully populated.

Interviewer: So how do you go about doing this job?

Respondent A: We normally hold a meeting to carry out a team Based Value Planning exercise. The team will normally use the paper based workbook as a reference manual from which to develop their own plan and adopt any relevant tools and techniques e.g. brain storming techniques for use during the meeting.

Interviewer: Do you reflect all the five values (customer, partnerships, people, innovation & technology, performance) in your team based value planning?

- Respondent A: No, not necessarily. We tend to choose one value and work with it. Sometimes we take two values at one go but not all five values. We also found the workbook helpful when trying to understand higher level plans in order to figure out how our plans at team level feeds into these higher level plans. That is the reason why we specifically asked for this feature to be included in the system [Enrich system].
- Interviewer: Are there tasks in which you still use the paper-based workbook?
- Respondent A: No, we don't use the workbook at all. We produced our own tailor made tool from the workbook that suits our needs and working style. We do not use the new tool (Enrich) much either.
- Respondent A: The original workbook is used only as a main source reference manual for teams to formulate their own plans ideas. One of the problems with using the old workbook is that there was no way of linking or getting feedback on the success or failure of its usage. There was no way of telling whether or not other teams are using it and if so how they are using it. Once we were asked to use it (old workbook) by management, the first reaction was to ask ourselves, what is wrong with the way we work now? Why introduce new guidelines for team value planning?
- Interviewer: What would you say is the main reason for not using the company workbook and the Enrich system?
- Respondent A: There are many reasons. To start with, our team members tend to work hand in hand with long term temporary staff hired through employment agencies. It is therefore difficult to give everybody equal access to all functions of the tool [Enrich system] due to differences in working terms and conditions. Then there is also the duration of contract for temporary staff, it just makes difficult to give equal access for security reasons even though they do the same job as the permanent EngiCom staff.
- Interviewer: So what do you think about the tool as an individual who has had chance to 'play' around with it and use it?

Respondent A: In my opinion, the new tool is not very useful for searching ‘best practices’ because these can change from time to time. Besides, we never consulted ‘best practices’ anyway. We don’t always refer to what other people have done anyway. For this reason, even the sharing of knowledge element of the new tool [Enrich system] is not valued much, even though benefits this could come to be appreciated once the tool has been widely used. In my view, the main uses of the new tool lie in the storage, access and distribution of documents. The only problem at the moment is the lack of usage by team members, maybe because they view the tool [Enrich systems] as another venture from management. EngiCom has been getting involved in many projects that have ended in failures within periods of six months or so. You see, these systems seem to be driven from the top to the bottom. At the bottom level it only works when there is a belief that it is a push from down to the top, which is the case with the idea of using ‘evidence’ to share knowledge about work.

Respondent A: We made a request for the tool [Enrich system] to facilitate the colour coding of the five values in the value plan to fit in with our working style. You see, we can easily identify each value by its own colour. For example, we already use coding to represent and differentiate company values in the ‘evidence file’. This could also be supported in this tool. The different colour coding schemes that we use are as follows:

Red - used to represent ‘Customer Value’
Blue - used to represent ‘People Value’

We selected and agreed on the use and meaning of this colour coding scheme as a team. The use of these colours is meaningful and informative to us. We would therefore prefer it if the system had the same colours for representing company values.

Respondent A: We believe the earlier ‘best practices’ and ‘discussion area’ functions of the Enrich system didn’t serve us well. We therefore started thinking about alternative uses of the tool [Enrich system]. In our old method of working we depended on sharing hard copies of documents. However, this method of sharing documents had a lot of access problems. For example, a report could be on someone’s drawer or shelf and then it could just get forgotten about, lost or even

missed and we kept searching. In such situations, we can now see how we can have used this tool [Enrich system] to store, update and track documents, which is really good.

Interviewer: What do you perceive to be important about the new tool [Enrich system]?

Respondent A: The key value of this system is that it has made things measurable by putting a process in place. Using this system, we can now try and work towards consistence across teams throughout EngiCom when doing the value planning exercise. We hold the view that value planning needs to become a 'living organism' with flexible objectives. The objectives that were originally set may change later on in the year. Therefore we need a tool that can allow us to review our value plans on regular basis instead of annually. The new tool [Enrich system] will also be good for generating initial plans. For example, the system can be used to support brainstorming activities using the 'discussion space' [debate area], which can be conducted prior to the actual meeting.

The other advantage of using this electronic version of the paper company workbook results from the convenience of being able to make changes directly and locally not through someone at headquarters. Then there is also the possibility of sharing documents e.g. a hard copy document can be transferred from one person to another in electronic format. It is really too early for us to comment on benefits of using the tool [Enrich system] because even though the tool is now available and accessible for use by everybody, there is lack of usage.

Interviewer: So in what other tasks do you use the new tool (Enrich)?

Respondent A: We also use the new tool when setting value plan objectives as a T-Pubs mainframe management tool. The only problem is that you always need to widen your screen because the system will always throw you at the top. This makes it difficult to trace where you are and where you are coming from once the screen starts scrolling down. The old workbook also had no means of providing feedback. On this new tool [Enrich], it would have been nice if you had also introduced a means of telling the number of people

using the tool may be through a counting mechanism upon access to the system.

Interviewer: Are there any restrictions to the way you currently work as a result of using the new tool?

Respondent A: Yes there are restrictions from EngiCom, mainly because the company gets flooded with new developments and information technology gadgets. We really don't like the idea of management jumping onto the band-wagon. The general attitude is that we have seen it all before and it is just a question of giving it time and it will die down within six months or so.

Interviewer: I realise that you have a newsletter in circulation; do you think it would be a good idea to include it as one of the documents whose delivery is supported by the new tool [Enrich system]?

Respondent A: People are so used to reading it (newsletter) in hard copy form. I suppose it could be printed out and sent to team members via internal mail. Once people are comfortable with using the system, we can then think about introducing an electronic version of the newsletter and let the team leaders point them (members) to where it (newsletter) is via email.

End of interview with T-Publications Leader (Respondent A).

Appendix B - 2

Interview with 'People Value' team member (Respondent B)

Respondent B works on the 'people value team' and also collaborates on other value teams. She has heard about the Enrich system. She has actually attended a couple of meetings in which the Enrich system was formally introduced with demonstrations of the functionality of interface features given. The respondent has had the software to run Enrich tools installed on her machine and was able to access the system and use it whenever she wanted.

Interviewer: Can you tell me what your team does and may be how you work?

Respondent B: I am responsible for organising group team meetings for the people value team.

Interviewer: How often do you hold these people value plan meetings?

Respondent B: We used to hold meetings on monthly basis but have not held any during the last two months because of what is happening in the organisation. The next meeting is due next week but I can't tell whether it will take place or not.

Interviewer: Do you use computer systems in some of your duties?

Respondent B: Yes we do use computers as you can see; almost everyone has a computer on their desk and can access many packages. We mainly use email for internal communications and the internet to search for company information.

Interviewer: Can you tell me a little bit more about how you use either the company workbook or the Enrich system?

Response B: We have developed our own method of planning using ideas from the paper-based company workbook. We do not use the new tool [Enrich system] during our planning. We feel the new tool is something pushed onto us from above [management]. We see the introduction of this new tool as an extra gadget that will introduce extra work. There is really no motivation to use it all. Morale is quite low at the moment because of what is going on in the organisation. A lot of changes and re-organisations are taking place at the moment such that people don't know whether or not they will have a

job next month, so why get excited about a new system if you don't know whether you will be here or not.

Interviewer: I understand you have had a try at using the new tool, do you think there are benefits to using it within your team or maybe on other teams that you collaborate with?

Respondent B: Oh yes, I can see the benefits of using the new tool [Enrich system] quite alright. It would be particularly useful for distributing documents and especially linking to 'evidence'. Unlike the paper-based company workbook, using this new tool also makes it easy to find relevant information.

The main reason why most people are not using it even though they have heard about it and seen it is due to lack of motivation from management. We feel that there are already too many things to do. The atmosphere in the organisation is leading to lack of motivation in using the new tool. Team members are uncertain about their jobs. There is a lingering threat of redundancies. Members feel they already have enough to do as it is. We don't understand why we should be given extra responsibilities of using a new tool that is also seen as a management's toy. If management want us to use it then they need to motivate us. As I mentioned earlier, we have not even had our 'people value' plan meeting for two months now. It is so chaotic at the moment.

End of interview with Respondent B.

Appendix B - 3

EngiCom Questionnaire

June 2000

Ideas on gathering data: Produce a plan for gathering data, (questionnaires, ideas for using the notion of functional organ). Field Study Plan

Research questions considered for use

- In what activities is the Enrich tool used?
- The focus is on mediators or tool.
- What role/s does the tool play in these activities?
- What is the goal or object of activity?
- Identify things (objects) that are going to be changed as a result of the introduction of the tool.
- How do they use these tools now?
- How do they see things changing in the way they work as a result of the new tool?
- What needs do the artefacts serve?
- What is the history of the use and development of these artefacts?
- What requirements are being satisfied?
- In thinking about the multi-levelled or hierarchical structure of computer use, what are the levels of interaction?
- Is there a shift in focus from interaction?
- What internal and external tools (resources) are used during activity in each one of the functional organs identified?
- How are these tools (resources) functionally integrated?
- Now consider how a computer tool could be included into the structure of the activity.
- What are the reasons for using a computer tool (in activity?)
- What is the goal or motive and conditions of the activity?
- What are developmental changes of the activity?
- What tools mediate activity?
- Investigate the relationship between collaboration and learning in the activity.
- What are the functional organs involved and being supported?
- What are the reasons for using a computer in each case?
- What tools (computer tools – interface representation, techniques, interaction methods) do we need to employ and how?
- How about the historical development of these tools (past, present and future)?
- Thereafter, consider how a computer tool could be included into the structure of the activity.

Some of the above *questions* will be used to aid the *observation* and *interview* processes. Other will be used to trigger thinking when operationalising concepts coming under the key notion of functional organs e.g. the idea of IPA.

<i>Activity level</i>	- ask <i>why</i> something takes place?	Focus on <i>Motive</i> or
<i>Objective.</i>		
<i>Action level</i>	- ask <i>what</i> takes place?	Focus on <i>Goal</i> .
<i>Operation level</i>	- ask <i>how</i> it is carried out?	Focus on <i>Condition</i> .

Appendix B - 4

Transcript of field notes made following a visit to one of EngiCom's plants

May 2000

About the Organisation

EngiCom operates in the aerospace industry. They manufacture engines, wings and other aeroplane body parts for both commercial and military purposes. The company employs thousands of people at its plants all over the UK. These employees work in the areas of engineering, sales, marketing, personnel etc. The division of labour within these areas is organised in a team structure. Team operations are organised around *five values* (Customer, People, Performance, Partnership and Innovation) identified by the organisation as to be crucial to its success. The organisation was trying to encourage the sharing of best work practices amongst employees through the sharing of work experiences and knowledge about work as a means for promoting organisational learning. In order to achieve this, teams are required to continuously *reflect* on their work practices by conducting team *value planning exercises* to *assess their performances* against the five values on regular intervals.

A paper based *workbook* or manual was introduced to support the value planning process and provide a means for recording team planning activities. In doing so, the organisation was enforcing a standard method for assessing team performances against the five values. The workbook incorporates the *value planning sheets* and *value scoring matrixes*. The value planning sheet is used for setting new objectives to be satisfied as well as recording decisions made on actions to be taken. The value scoring matrixes on the other hand are used to assess whether or not the objective set has been met. This is achieved through rating and recording scores on each value. During the value planning exercise, a team would normally hold a meeting to evaluate its performance against any of the five values by indicating the current level of performance, thereafter, setting a future target to be achieved.

Even though, the organisation had standardised the performance assessment method employed by the teams using the workbook, team leaders and their teams developed their own ways of working with the paper-based workbook. They perceived and used the workbook as a reference manual from which they could generate ideas on how to develop and apply their own performance assessment methods and techniques. Some of the assessment techniques applied by some of the teams includes the 'plan-do-review' process that entails the team leader working out a plan on how the assessment is going to be carried out. Once the plan has been outlined by the team leader, the rest of the team would then participate in the actual 'doing' of the assessment and 'reviewing' process. In preparing the plan, the team leader would draw from previous experiences, higher level plans and current operations to be carried out within the team. Other teams tend to take a bottom-up approach by planning from the perspective of their own current working methods. They then

move on by deciding how their approach fits in with the method presented in the workbook. In such cases, evidence from studies being carried out seem to suggest that, instead of adopting and adjusting to the top-down approach presented in the workbook, teams using the bottom-up approach tend to change the method presented in the workbook to fit in with their own approaches.

Appendix B - 5

Plan and reflections on data gathering and analysis method to be used at EngiCom field study

June 2000

Aim

- To gather field study data.
- To contextually understand activity (work practices, collaborations and learning) in terms of what people do (how they collaborate and learn while working).

Strategy (Method, how?)

- Qualitative data collection techniques.
- Semi-structured interview using questionnaires.
- Design some tasks for use as part of the Observations to trigger questions and comments.
- Software logging (Enrich, EngiCom Server)
- Ethnography-by-proxy (EngiCom Enrich Representative from headquarters, Team Leaders)

Procedure

- Briefing on activity (Tape record, Make Notes)
- Observing participants, look out for:-
- Collaboration, Cultural norms in communication and practice, co-operation, sharing, consulting.

Tools to be used

- Open-ended questionnaire
- Note pad
- Pen or Pencil
- Audio Record
- Digital Camera

Appendix B - 6

Research questions considered

Identify activities – by asking ‘what’ type questions.

- So what do you do in your team?
- Briefly explain how you normally go about it.

Identify actions - by asking ‘how’ type questions.

- How do you share knowledge and skills about work?
- How do actions feed into each other's work?
- Do you normally collaborate (while working) or share knowledge about work?

Identify operations - by asking ‘what’ type questions.

- Other than the workbook, are there *rules* or guidelines that you follow while working?
- Are there any influences from the *community* that affect the way you collaborate and share knowledge?
- Do these change from time to time?
- Do you sometimes work competitively?
- If so, how does that affect the sharing of ideas?
- Do you expect to see changes in the way that you work as a result of the new tool?
- What do you expect to change as a result of using (Erich) tool?
- What *tools* do you normally use, when, how and why?
- What is your understanding of the purpose of the tool?
- What would you say will be the main uses of the new tool within your team?

- What is the *main activity*?
- What is the *objective* of the activity?
- What *tools* are used in that activity and why?
- How do they use these tools now?
- How do they normally carry out such activities and why?
- In what activities is the Enrich tool used?
- What role/s does the tool play in these activities?
- Identify things (objects) that are going to be changed as a result of the introduction of the tool.

- What needs do the tool serve?
- What is the history of the use and development of these tools?
- What restrictions exist from the *community, rules* and *division of labour*?
- In thinking about the multi-levelled or hierarchical structure of computer use, what are the levels of interaction?
- Is there a shift in focus from interaction?
- How are the tools (resources) functionally integrated?
- Now consider how a computer tool could be included into the structure of the activity.

- What are the reasons for using a computer tool (in activity?)
- What are the conditions in which tasks are operated?
- What are developmental changes of the activity?
- Investigate the relationship between collaboration and learning in the activity.
- What are the functional organs involved and being supported?
- What are the reasons for using a computer in each case?
- What tools (computer tools – interface representation, techniques, interaction methods) do we need to employ and how?
- How about the historical development of these tools (past, present and future)?
- Thereafter, consider how a computer tool could be included into the structure of the activity.

Actors (Doers)		Mediator		Goal (Motive)
Subject	~	Tools	~	Object-ive
Subject	~	Rules	~	Object-ive
Subject	~	Division of Labour	~	Object-ive
Community	~	Tools	~	Object-ive
Community	~	Rules	~	Object-ive
Community	~	Division of Labour	~	Object-ive

Appendix B - 7

Field Notes – EngiCom Field Study

July 2000

Procedure

- b) Outline the objective of the study
- c) Get a briefing
- d) Ask questions to maintain flow of conversation

Aim

To *understand how the team works* before, during and after the introduction of the Enrich tool. Information will help in deciding on issues to consider when developing and introducing a computer tool in a work practice. In this case issues relating to how to adequately support work practice using a computer tool? How to manage and improve the way the tool supports work through its (tool) design?

Focus areas:

- Collaboration, Knowledge Sharing, Cultural norms, Learning, Co-operation, Consulting

Briefing

Could you tell me a bit about your team in terms of :-

- 1) What the team does?
- 2) What is the *goal or purpose* of this activity?
- 3) How does the team normally carry out these activities and why?
- 4) How does the team's work fit in with other teams' activities at this plant or in the wider EngiCom community
- 5) What kind of *tools* do you normally use when performing this activity (when, how, why)?
- 6) Is there a *history* to the use and *development* of these tools?
- 7) What would you say are the *reasons* for introducing a computer tool (in this activity)?
- 8) What is your understanding of the *purpose* of the new tool?
- 9) In what activities is the Enrich tool used?
- 10) What do you *like or dislike* about the new tool?
- 11) What do you see as the *main uses of the new tool* within your team?
- 12) Do you expect to see *changes* in the way you work as a result of the new tool?
- 13) Do you normally *collaborate or share knowledge* about work (within or outside your team)?
- 14) Do you sometimes work *competitively*? If so, how does that affect the sharing of knowledge?
- 15) Other than the workbook, are there any *Rules* or guidelines that you follow while working?

- 16) Are there any restrictions or influences from the *Community, Rules or Conditions* and *Division of Labour* that affects the way you work or share knowledge about work?
- 17) Do these change from time to time?

Appendix B - 8

Field Notes

(3rd April, 2000)

To access the EngiCom Enrich Tools
<http://Enrich.open.ac.uk:3000/workbook>

then type either of the below in the box for CSD

-EngiCom-user (will allow one to browse casually)

CSD is the higher level plan/

- tech-pubs

February, 2000

This document reflects an account of the initial visit to a EngiCom plant in for the purpose of demonstrating the Enrich 'Workbook' tool. A demonstration of features and functionality of the tool was necessary so that the user who included team leaders and middle management operating at different levels. The idea is to introduce the tool to them as final users. So that they can assess how the tool would fit in which how they work, identify conflicting areas in terms of the way the tool is to be used and how it can be integrated with already existing systems. Following a demonstration of the tool, the following issues arise:

- e) A comment was made about the interface on the tick sign used for indicating both the current level and 'where we want to be' level. The users asked to have the maker differentiated in such a way the 'this is where we are' is represented by a different icon maker to that of 'where we want to be'. For example through the use of an X and a tick for the other. Other ideas generated on this issue of distinguishing the maker includes the use of colour or radio buttons etc.
- f) It was also suggested that the success of the use of the tool would be dependent onto how the user uses the tool in terms of the success of the search for best practises. At the moment the tool uses the two scores information together with key words picked from the objective description as a guide as to want best practises to pull out as matches.
- g) A query was raised as to the problem of handling several objectives. "We normally have several objectives to meet, using the tool, are we restricted to searching on best practices relating a single objective at a time or can we do multiple objectives?" The answer given was that using several objectives would make the generated results difficult tell which objective a recommended best practice search result relates to. Therefore, at the moment, a single entry search is recommended. Of course this means that several runs of searches will have to

be carried out in order to cover all objectives if one has for example ten objectives.

- h) Another interesting point raised relate to the linking of internal objectives to the overall objectives say at management level. Internal teams wanted a way of linking or telling how their local or internal objectives fed into the bigger picture at the next higher level. That way they say they can manage and update the master plan-file if need be. They also have an idea into how things fit together. This they say would also help to understand where they are in relation to where they have to be during their future planning. Making this link visible through the interface and functionality of the tool it was argued would reduce problems relating the duplication of effort as all teams can see what is being done by who, and, at what level and where they are meant to be finally.
- i) Another interesting development was the request for a functionality to summarise all the information which has been entered in the forms in a report format. It (Jim) was argued this would serve as a quick summary of issues that can be understood at a glance or even handed over to management for reference etc.

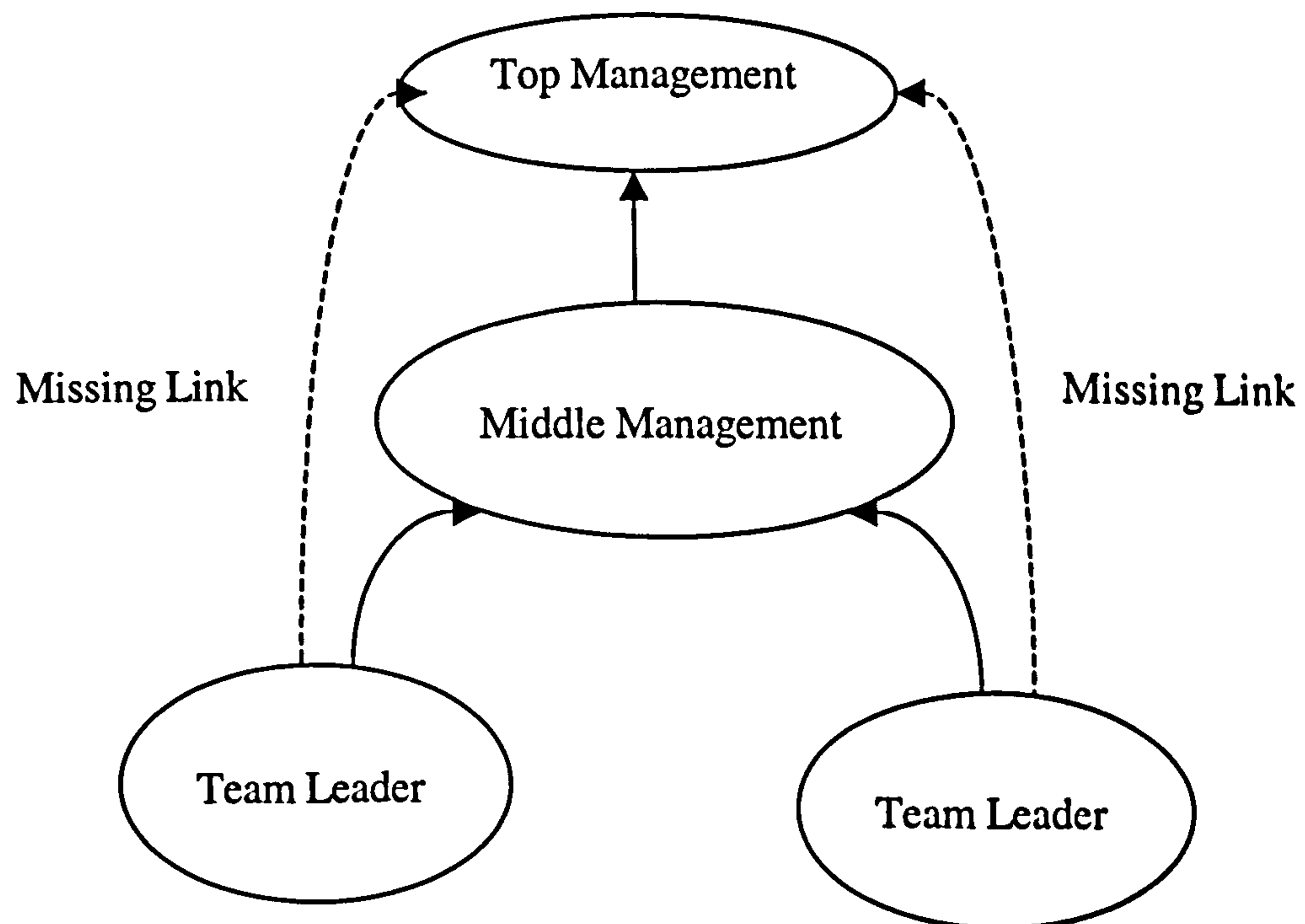


Figure shows the 'Missing Link'.

- j) It seems an initial brain storming session will take place then the tool will only be used to record and reaffirm what was decided upon during the team meeting. I wonder whether the tool can be used or restructured to support the process of brain storming so as to capture context.

Appendix B - 9

Field Notes

April 2000

These notes were made following a visit to one of EngiCom's manufacturing plants. The purpose of the visit for was to familiarise with the work practices and environment through *observations* in order to get an insight into the operations of the organisations. Also to try and analyse the work situation in terms of organisation, division of labour, tools and rules in place. This information would help me in deciding what questions to ask when conducting the *interviews* later on.

During this visit the 'customer value team' was holding a customer value meeting. The team leader had just changed job roles and a new team leader who has had a look at the tool was just taking over team leadership.

The meeting involved evaluating the interface of the EngiCom enriched computer tool by the team members who are going to use it to see whether it fits in with their working methods. The team members needed to know how to edit the tool features, e.g. adding and removing or updating content. They also wanted to know what level of usage was required in order to be familiar with the tool and also up to date with what is happening. Questions relating to navigation and orientation were asked e.g., is it possible to highlight where you are on the menu index as you browse through the document. The team enquired about the possibility of colour coding text that the user types into the form interface as they interact with the tool as a way of highlighting things in the boxes. (Text typed in by the user cannot be colour coded by user? The CGI script that processes the form and content can probably produce colour coded text?) The team also wanted to have a means for linking to the document with 'evidence' or 'referencing' from the discussions in the discussion space. This evidence or referencing could be in the way of linking electronic documents as in html hyper-links, downloadable files, or simply information revealing where what information can be found and why. The team envision future uses of the Enrich system as a document management tool. There was a suggestion to review the inclusion of the visual clue icons on the discussion space in the way of 'agree – thumbs up', 'disagree – thumbs down' etc. The team felt these increased the interactive features, therefore, adding to the confusion that already existed as a result of using a new tool. The team worried that the increased features should only be included if they are necessary to the functions of the tool and contribute positively to the successful operation of tasks. This was decided upon in order to cut on the amount of training and things to be mastered before one can confidently use the tool.

The meeting ended with the team asking for time to try out the tool by themselves in order to have a feel of how it works and how it will fit in with how they work. From this experience, they would decide on training and maintenance matters of which another visit would need to be arranged.

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EngiCom Value Planning Sheet

PLANNING SHEET

	OBJECTIVES	ACTIONS	MEASURES	WHEN (START AND END)	WHO
CUSTOMERS					
PEOPLE					
PERFORMANCE					
PARTNERSHIPS					
INNOVATION & TECHNOLOGY					

Workbook Do, Issue 1, June '97.

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EngiCom Value Scoring Matrix

WHERE ARE WE NOW AGAINST OUR VALUES?

Read the descriptions against each value and mark the box you feel best reflects your current position. Repeat the exercise, indicating where you want to be. Agree a timescale

Customers – Our highest priority	We have little or no understanding of who our customers are and what we provide to them.	We know our customers and the products and service we provide but have only an internal view of customer needs.	We understand customer needs which are documented. Measurement is rarely to these needs. We recognise the need for action but none are in place.	We have actions in place and measure performance to customer needs. Trend data is collected, is actively involved and we recognise the need for some agreement.	We have agreements with the customer, built around key areas, and regularly survey the customer's perception of our performance as part of our suite of measures.	BY WHEN	COMMENTS
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Partnerships – Our future	We have little or no understanding of who our partners are and what we provide to each other.	We know our partners and the product / service we provide to each other. We don't have any working relationship.	We have a working relationship with our partner. We have identified improvement actions but no measures to monitor progress.	We have agreement in place that sets the standards expected from each other. We regularly review with our partners and monitor performance to the agreement.	We have agreements and measures with our partners around key areas. We regularly review to identify areas for improvement.	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
People – Our greatest strength	We don't have skills and knowledge to meet our objectives. I can manage my team to deliver.	We have some awareness of our team's processes. We know what we do and how we do it as a team are different.	We only have trouble when two or three of the team are absent.	We meet our objectives and satisfy our customers' needs but we haven't learned to anticipate and meet their future needs.	Members of the team share skills and knowledge and team development is included in the plan which shows how they will be equipped to meet tomorrow's opportunities.	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Innovation & Technology – Our competitive edge	We do not encourage change to our processes. We don't see the need to change.	We have some ideas on how to improve, but are unsure how to implement them.	We actively listen to each others ideas and suggestions. Continuous improvement is recognised and rewarded within the team.	We are empowered to implement changes to our processes. We receive and share information on improvement ideas within and outside our team and Business Unit.	We take full advantage of technology to continually improve our efficiency. The team environment encourages the generation and explanation of new ideas.	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Performance – Our key to winning	We are unaware of our team's processes. We have no measure of team performance.	We have some awareness of our team's processes. We know what actions the team could take to improve but we haven't created a plan.	We have documented processes. We have a prioritised team plan and recognise the need for measures to review progress.	We incorporate customer needs and supplier capabilities in our team plan. We use EQM to measure progress and results are communicated. We contribute to the Value Plan.	We have agreed sets of measures with customer. We regularly review our progress against the plan, which ensures we are always delivering business improvement. We clearly publicise our results.	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>